Longmont Astronomical Society

March 2024

Lower's Nebula
by Rolando Garcia

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Next LAS Meeting March 21 at 7 pm

Cepheid Variable Stars by Dr. Charles Kuehn

Summary

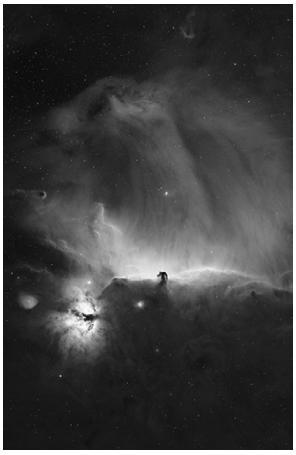
In his play Julius Caesar, Shakespeare had Caesar utter the line "I am as constant as the Northern Star." While poetic, this line isn't remotely accurate by astronomy standards. Not only does the star that happens to be the "North Star" change over time, the star that is currently the North Star, Polaris, is a Cepheid variable star, a class of variable star that changes in brightness due to the star physically pulsating. Since their discovery in 1784, Cepheids have become one of the most important tools of astronomers, allowing Edwin Hubble to discover that the Universe is expanding, providing important clues about the internal structure of stars, and allowing a way to study the evolution of stars over short time periods. In this talk we will look at what causes Cepheids to pulsate and talk about their important role in modern astronomy.

Bio

Dr. Charles Kuehn is an Associate Professor of Astronomy at the University of Northern Colorado. He earned his B.S. in Astronomy from The Ohio State University and his PhD in Astronomy and Astrophysics from Michigan State University before completing a postdoc at the University of Sydney in Australia. His research focus on the study of variable stars in an effort to understand stellar evolution, the formation of the Milky Way, and to determine the physical properties of stars that host exoplanets. He also engages in astronomy education research aimed to increase the accessibility of astronomy labs at the university level. He is passionate about outreach and runs a quarterly series of physics and astronomy talks at Loveland Aleworks.

The meeting will be at the First Evangelical Lutheran Church, 803 Third Avenue, Longmont, CO 80501. The speaker is planning on presenting in person. If you cannot attend the in-person meeting, it will be available on Zoom.

On the front cover is Rolando Garcia's image of SH 2-261, Lander's Nebula. It is a faint hydrogen emission nebula located in constellation Orion. Exposure was ~2 hours with the IDAS NBZ filter, SVX102T with a reducer/flattener, about 600 mm fl. after slight cropping.



On the back cover is Marty's good bye to winter image of the Horsehead and Flame Nebulae.

He took this from Hygiene with a Takahashi FSQ 130 on an AP Mach2 mount with an ASI 6200 camera.

45 x 10 minute subs in H-alpha.

About LAS

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Back Cover	"Horsehead and Flame Nebula" by Martin Butley

Planets in March

Mercury

Mercury becomes visible in the evening sky about 7:40 pm after the 12th. It will be difficult to see even at magnitude -1.2 in apparent brightness and 5.6 arc sec across. As the month progresses it is more easily seen as it is higher up. It will then be +0.9 magnitude in brightness but 8.8 arc sec across.

Venus

Venus is visible in the morning sky low in the southeast the first week in March. It then disappears into the bright twilight and not visible for the rest of the month.

Mars

Mars is visible very low in the ESE. It is +1.2 magnitude in brightness and only 4.3 arc sec across. Mars opposition is January 15, 2025.

Jupiter

Jupiter is visible in southwest after sunset. It is magnitude -2.2 in brightness; the apparent disk size decreases from 36 to 34 arc seconds this month. The following are favorable times to view the Great Red Spot at mid transit this month (above 20° altitude):

- Mar 1 at 8:48 pm at altitude 24°
- Mar 4 at 7:19 pm at alt 50°
- Mar 11 at 8:08 pm at alt 37°
- Mar 18 at 8:58 pm at alt 23°
- Mar 23 at 8:09 pm at alt 30°

Saturn

Saturn is not visible this month.

Uranus

Best time to view Uranus is around 8 pm in March. It is in constellation Aries; it is magnitude +5.8 in brightness and the disk is 3.5 arc sec across.

Neptune

Neptune is not visible this month.

Lunar Phases in March

- Third quarter: March 3 at 8:25 am
- New moon: March 10 at 3:02 am
- First quarter: March 16 at 10:12 pm
- Full moon: March 25 at 1:01 am

Meteor Showers in March

No major showers this month.

Showpiece Objects in March

Some early evening showpiece objects for mid March:

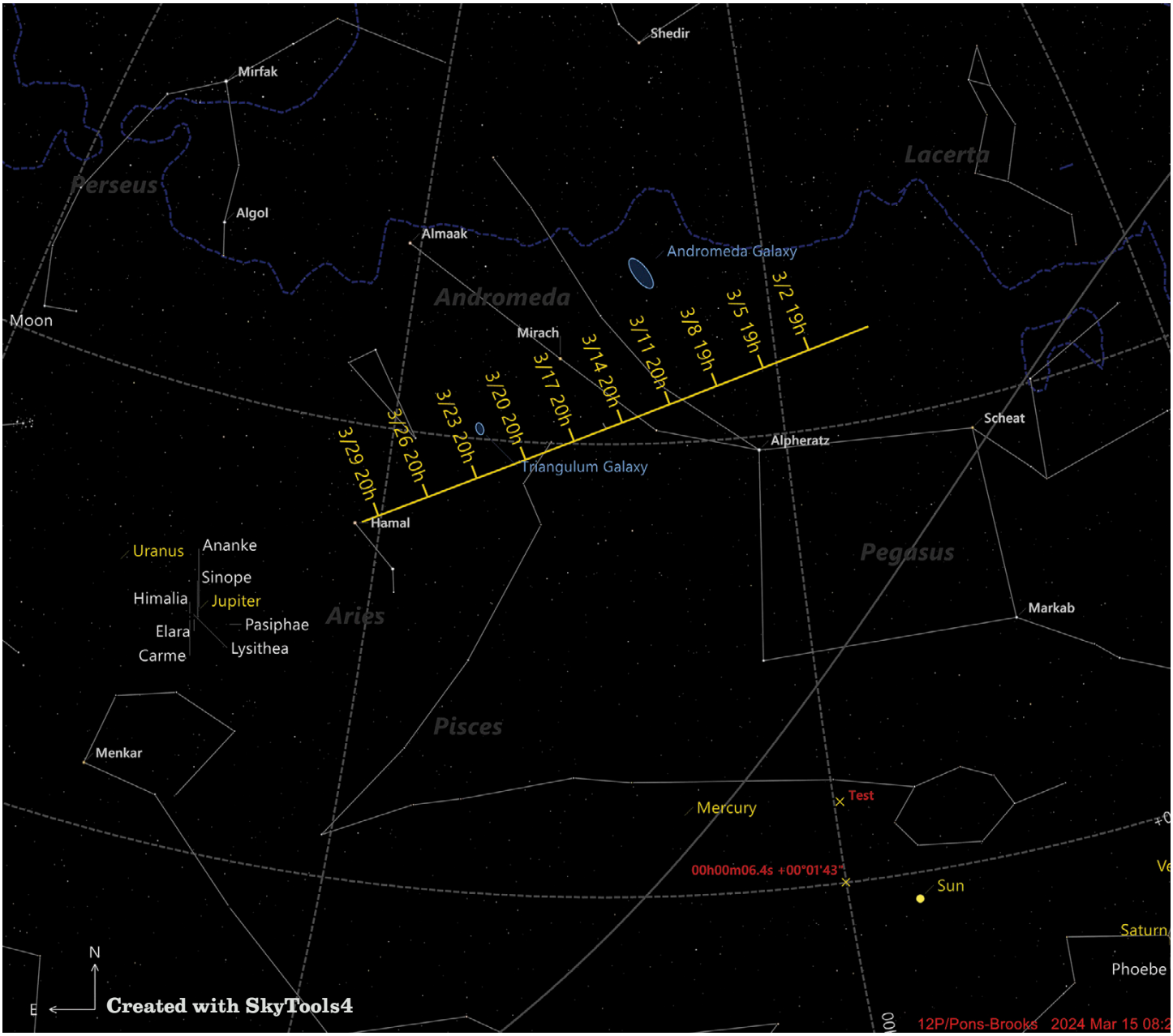
- Orion Nebula, M 42, in Orion, mag 4.0
- Bee Hive, M 44, Open Cluster in Cancer, mag 3.4
- M 41 Open Cluster in Canis Major, mag 4.3
- M 47 Open Cluster in Puppis, mag 4.4
- M 81 Bode's Galaxy in Ursa Major, mag 7.8
- Pacman Nebula, NGC 281, in Cassiopeia, mag 7.4
- Heart Nebula, SH 2-190, in Cassiopeia, mag 6.5
- Soul Nebula, IC 1848, in Cassiopeia, mag 6.5
- Maia Nebula, NGC 1432, in Taurus, mag 3
- California Nebula, NGC 1499, in Perseus, mag 5
- NGC 1931 nebula in Auriga, mag 11.2
- Crab Nebula, M1, Super nova remnant in Taurus, mag 8.4
- Horsehead Nebula, Barnard 31, in Orion, mag 16.5
- Flame Nebula, NGC 2024, in Orion, mag 10
- Rosette Nebula, NGC 2237, in Monoceros, mag 9
- Cone Nebula, NGC 2264 in Monoceros, mag 3.9
- Thor's Helmet, NGC 2259 in Canes Major, mag 11.4

Messier Marathon

Do you love staying up all night? The Messier Marathon weekend this year is March 9 -10. That evening it is supposedly possible to view all 110 Messier objects. Best I ever did was 108; I haven't been able to get the first object, M77, though I should have been able to. I have doubts that the last object, M30, is even do-able from here in Colorado as it rises only 30 minutes before the sun. Give it a try sometime -- it is fun to do.

Comet 12P/Pons-Brooks in March

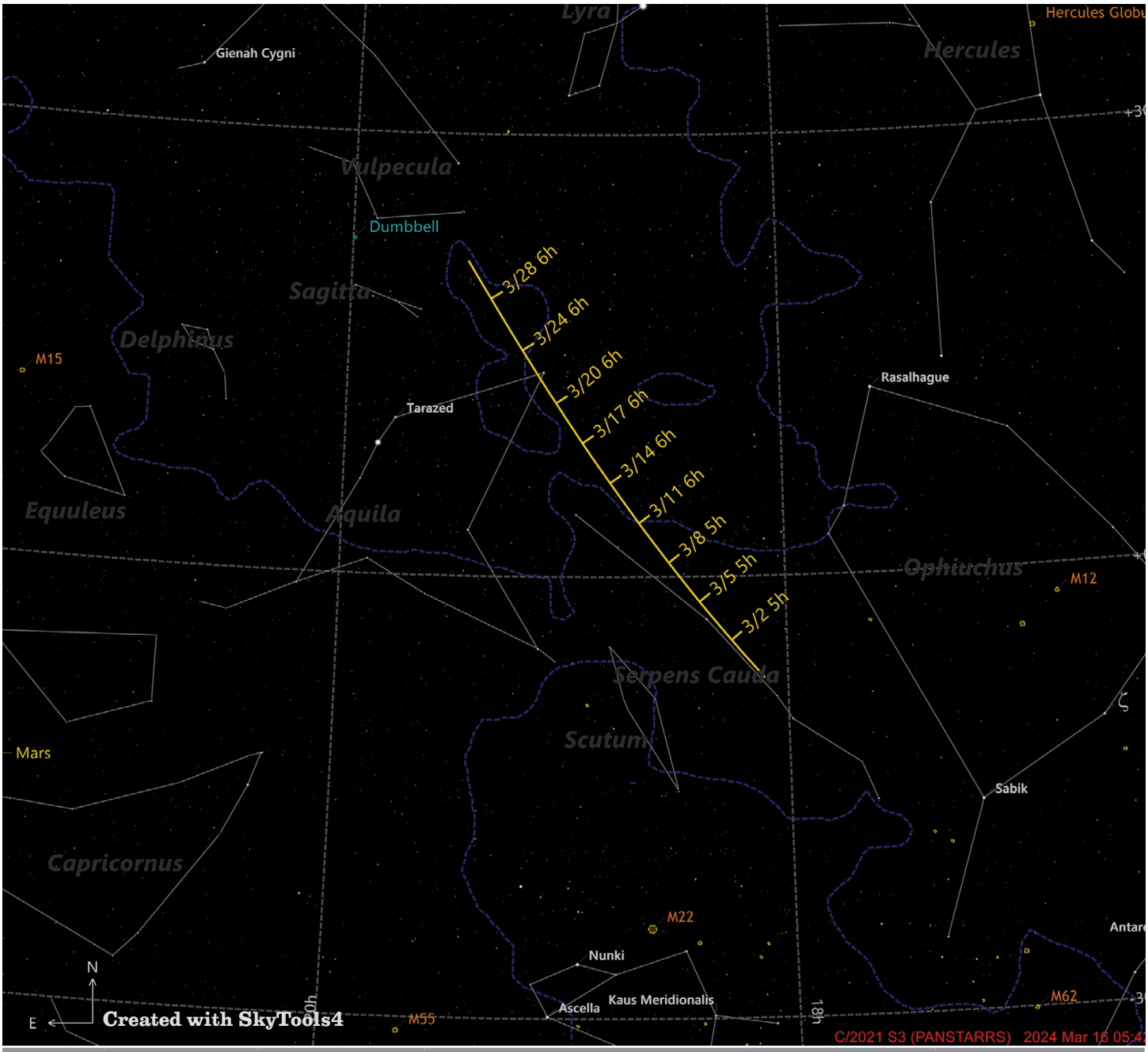
Comet 12P was discovered on July 12, 1812 by Jean-Louis Pons at the Marseilles Observatory. It was recovered in 1888 by William Brooks an American astronomer at his own observatory in Phelps, NY. Brooks discovered 27 comets in his lifetime -- second only to Pons who discovered 37. 12P is a periodic comet with an orbital period of 71 years. It is now magnitude 6.6 in brightness with a 7.5 arc min wide coma; it currently in constellation Andromeda. It is notable for its coma which is distorted into shape of a horseshoe or horns, hence its nickname, the devil comet.



Date	Optimal time	RA	Dec	Constellation	Magnitude	Size (arc min)
Mar 1	7:09 pm	23h45m09.5s	+35°36'52"	Andromeda	6.6	7.5
Mar 8	7:16 pm	00h20m55.9s	+33°41'26"	Andromeda	6.2	7.6
Mar 13	8:20 pm	00h46m12.3s	+31°56'18"	Andromeda	6.0	7.7
Mar 19	8:24 pm	01h15m46.4s	+29°25'05"	Pisces	5.7	7.8
Mar 25	8:29 pm	01h44m08.1s	+26°27'41"	Pisces	5.4	7.8
Mar 31	8:34 pm	02h11m01.7s	+23°06'37"	Aries	5.1	7.8

Comet C/2021 S3 (PANSTARRS) in March

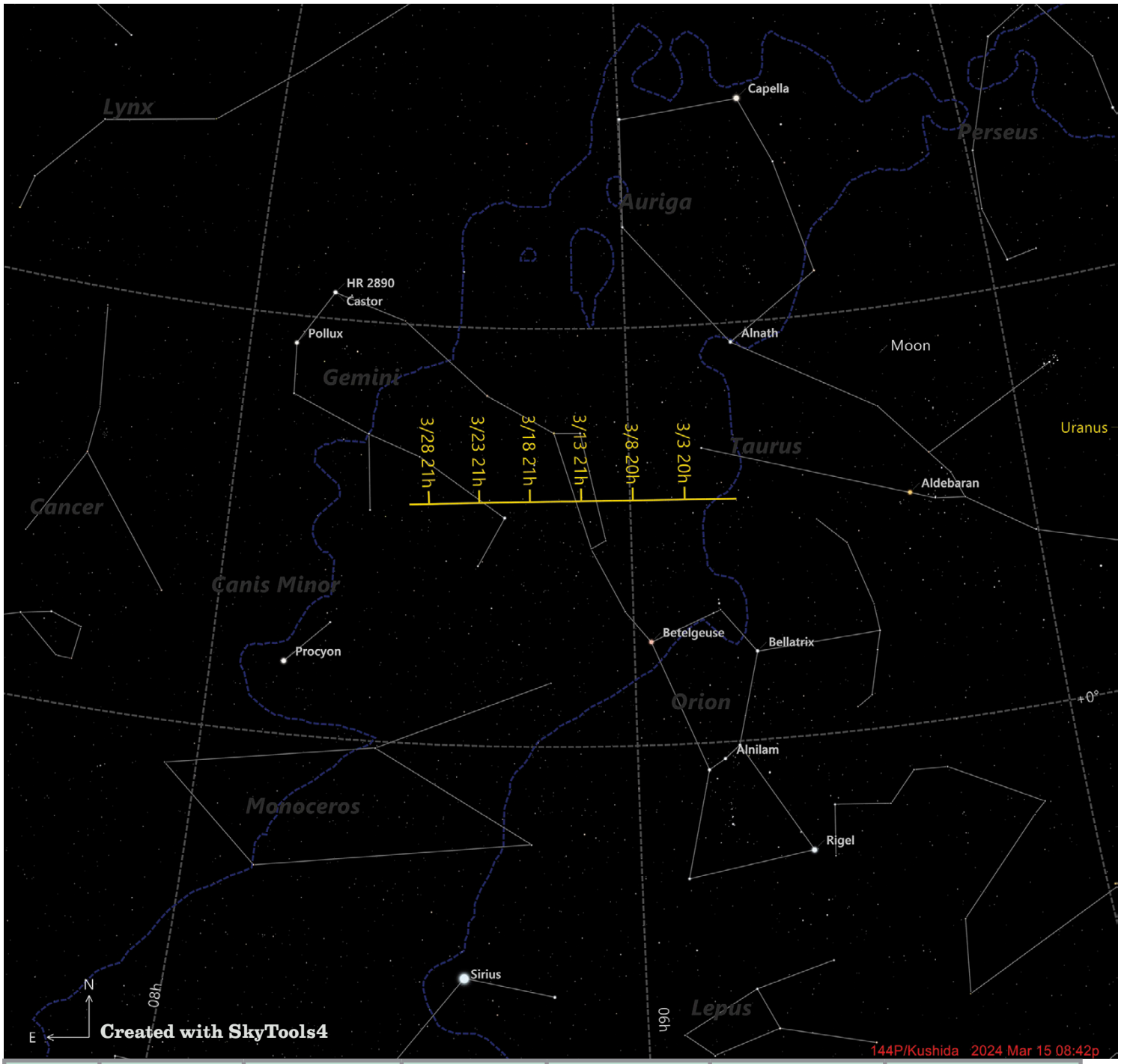
The Pan-STARR1 and Pan-STARRS-2 1.8 meter diameter telescopes are both located near the summit of Haleakala on the Island of Maui. The Pan-STARRS1 telescope is equipped with a 1.4 billion pixel digital camera. The camera on Pan-STARRS2 is 1.5 billion pixels. C/2021 S3 is now magnitude 10 in brightness in constellation Scorpius.



Date	Optimal time	RA	Dec	Constellation	Magnitude	Size (arc min)
Mar 1	5:07 am	18h16m00.6s	-04°19'16"	Serpens	9.7	2.1
Mar 8	4:54 am	18h35m09.0s	+01°53'00"	Serpens	9.8	2.1
Mar 13	5:46 am	18h48m10.2s	+06°24'14"	Serpens	9.8	2.1
Mar 19	5:36 am	19h03m02.8s	+11°49'22"	Aquila	9.8	2.1
Mar 25	5:27 am	19h17m04.7s	+17°08'11"	Sagitta	9.9	2.1
Mar 31	5:12 am	19h30m12.6s	+22°15'07"	Vulpecula	10.0	2.1

Comet 144P/Kushida in March

Comet 144P was discovered by Yoshio Kushida at the Yatsugatake South Base Observatory in Japan in January, 1994.

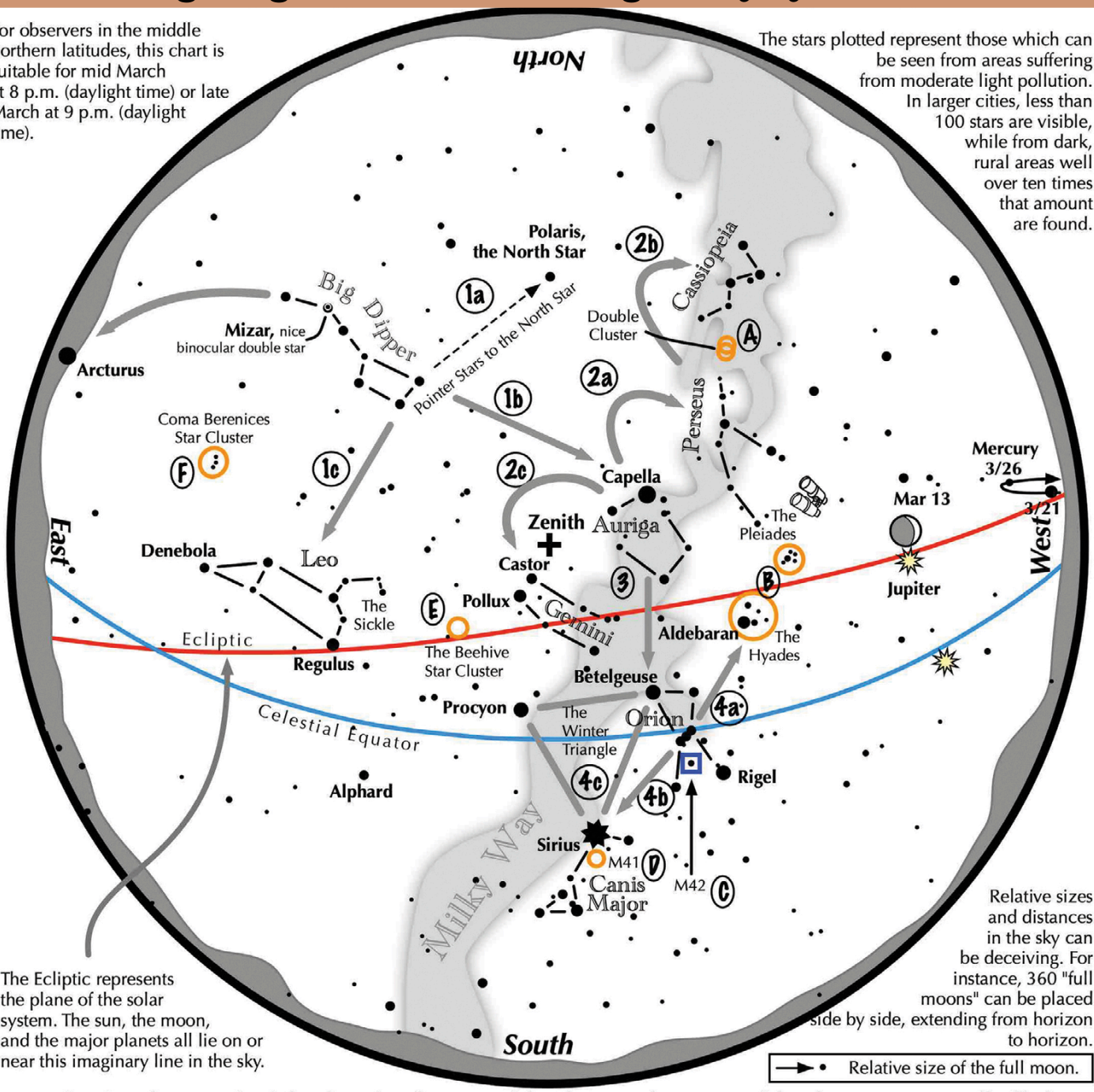


Date	Optimal time	RA	Dec	Constellation	Magnitude	Size (arc min)
Mar 1	7:30 pm	05h38m41.1s	+17°28'54"	Taurus	10.8	2.9
Mar 8	7:37 pm	06h00m32.9s	+17°36'48"	Orion	11.2	2.7
Mar 13	8:41 pm	06h16m07.6s	+17°37'09"	Orion	11.5	2.6
Mar 19	8:47 pm	06h34m39.8s	+17°31'30"	Gemini	11.9	2.5
Mar 25	8:40 pm	06h52m53.4s	+17°19'19"	Gemini	12.3	2.3
Mar 31	9:00 pm	07h10m48.2s	+17°00'47"	Gemini	12.8	2.2

Navigating the mid March Night Sky by John Goss

For observers in the middle northern latitudes, this chart is suitable for mid March at 8 p.m. (daylight time) or late March at 9 p.m. (daylight time).

The stars plotted represent those which can be seen from areas suffering from moderate light pollution. In larger cities, less than 100 stars are visible, while from dark, rural areas well over ten times that amount are found.



The Ecliptic represents the plane of the solar system. The sun, the moon, and the major planets all lie on or near this imaginary line in the sky.

Relative sizes and distances in the sky can be deceiving. For instance, 360 "full moons" can be placed side by side, extending from horizon to horizon.

Relative size of the full moon.

Navigating the March night sky: Simply start with what you know or with what you can easily find.

1. Above the northeast horizon rises the Big Dipper. Draw a line from its two end bowl stars upwards to the North Star. Its top bowl stars point west to Capella in Auriga, nearly overhead. Leo reclines below the Dipper's bowl.
2. From Capella jump northwestward along the Milky Way to Perseus, then to the "W" of Cassiopeia. Next jump southeastward from Capella to the twin stars of Castor and Pollux in Gemini.
3. Directly south of Capella stands the constellation of Orion with its three Belt Stars, its bright red star Betelgeuse, and its bright blue-white star Rigel.
4. Use Orion's three Belt stars to point northwest to the red star Aldebaran and the Hyades star cluster, then to the Pleiades star cluster. Travel southeast from the Belt stars to the brightest star in the night sky, Sirius. It is a member of the Winter Triangle.

Binocular Highlights

A: Between the "W" of Cassiopeia and Perseus lies the Double Cluster. **B:** Examine the stars of the Pleiades and Hyades, two naked eye star clusters. **C:** M42 in Orion is a star forming nebula. **D:** Look south of Sirius for the star cluster M41. **E:** M44, a star cluster barely visible to the naked eye, lies to the southeast of Pollux. **F:** Look high in the east for the loose star cluster of Coma Berenices.

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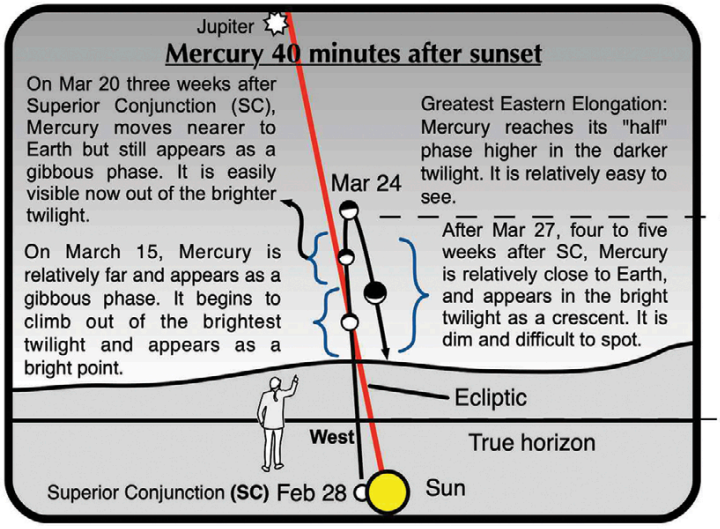
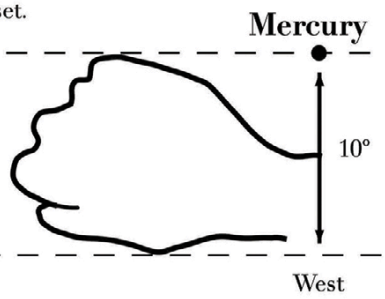
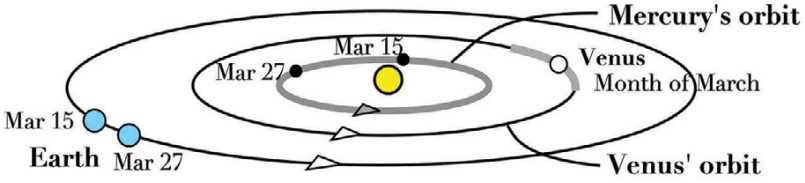


Mercury in the Evening!

Mercury appears about "1 fist width on a fully extended arm" above the true horizon forty minutes after sunset.



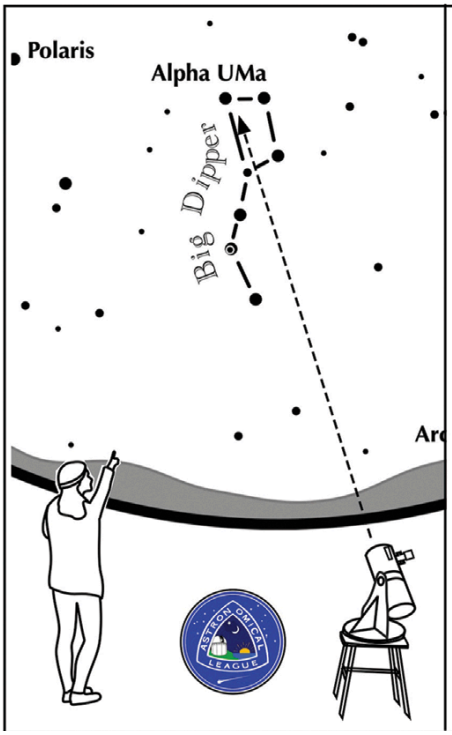


Mercury's best evening apparition of 2024!

From 40 to 60 minutes after sunset after March 15th, look to the west for a point of light shining low above the horizon.

- Outstretch your arm and make a fist. Place one side at the true horizon. At it its other side should be Mercury.
- Over the next week, the little planet rises slightly higher each evening into the darker twilight while brightening, making it easier to spot.
- On the 24th, Mercury appears as far from the set sun as it will be. This point in its orbit is called Greatest Eastern Elongation. Just three nights later as it descends in the twilight, it will become much more difficult to spot.

ASTRONOMICAL LEAGUE Double Star Activity



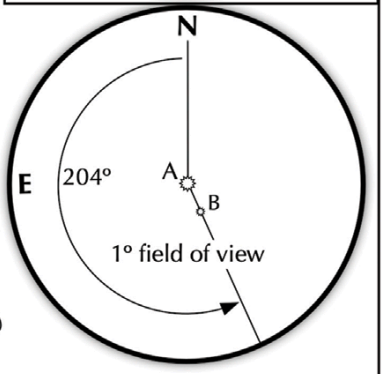
Other Suns: Alpha Ursae Majoris

How to find Alpha Ursae Majoris on a March evening

Face northeast. Look for the Big Dipper standing upright on its handle. Alpha is the star on the upper left corner of the bowl.

Suggested magnification: >20x
Suggested aperture: >3 inches

Alpha UMa
A-B separation: 381 sec
A magnitude: 2.0
B magnitude: 7.0
Position Angle: 204°
Colors:
orange
dark orange



Try binoculars!

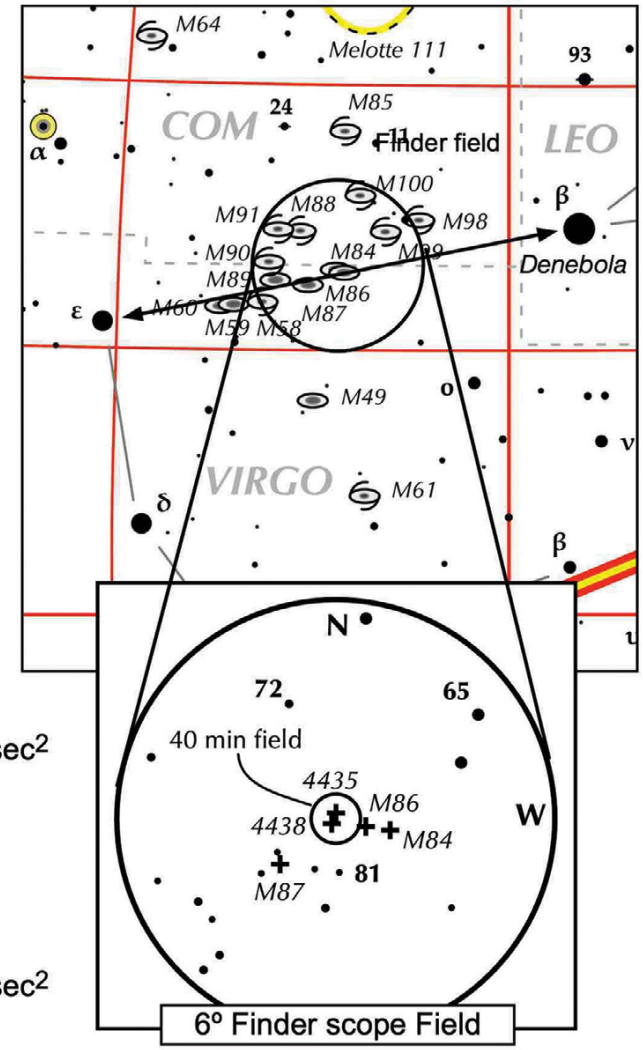
Said to be one of the eeriest sights encountered in galaxy observing.

NGC 4435 & 4438

"The Eyes"–Two Spiral Lenticular Galaxies

Navigate to NGC 4435 & 4438

1. Find Beta Leonis (Denebola) and Epsilon Virginis (Vindemiatrix).
2. Draw a line from Beta to Epsilon.
3. M84 and M86 lie at the mid point of that line.
4. NGC 4435 & 4438 glow about 40 minutes east of M86.
5. In a 40 minute field, they appear as two eyes staring back in the blackness of space.



Bonus Galaxies:

The region abounds in galaxies: M84, M86, M87, and many fainter ones.

Recommended Aperture:

Not less than 10 inches. The larger, the better.

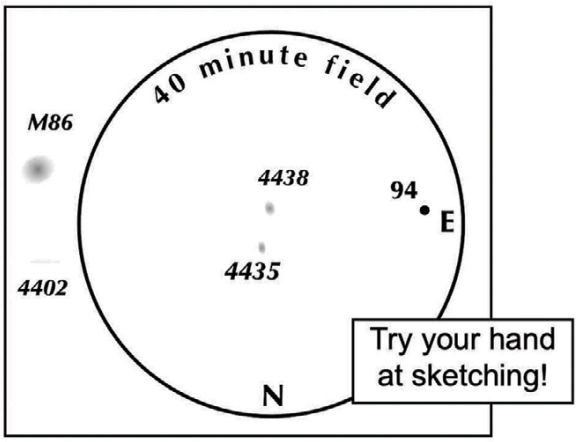
Yes, they do resemble two eyes staring at you from the blackness of space!

Published Characteristics for NGC 4435

Integrated magnitude: 11.7
Size: 2.8 min x 2.0 min
Surface brightness: 13.7 mag./min^2, 22.6 mag./sec^2
Position Angle: 10°
Distance: 52 million light-years

Published Characteristics for NGC 4438

Integrated magnitude: 10.6
Size: 8.6 min x 3.2 min (bright core, faint tails)
Surface brightness: 15.0 mag./min^2, 24.0 mag./sec^2
Position Angle: 20°
Distance: 52 million light-years



Eyepiece Impressions:

NGC 4435: Very small, elusive. Uniform brightness. Use averted vision. Near NGC 4438 and located 25' east of M86. (6-inch Cass.; ACAC)
10 inch f/10 SCT, 125x: "NGC 4435 is slightly elongated with a bright center." JG

NGC 4438: Extremely elongated, uniform brightness, very large. Use averted vision. Located 4' south of NGC 4435. (6-inch Cass.; ACAC)
10 inch f/10 SCT, 125x:"NGC 4438 is elongated with a brigth center. Under careful observation, wispy outer regions are noticed." JG

LAS February 15 Meeting Notes by Eileen Hall-McKim

I. Introduction

The February LAS monthly meeting was held in-person and by Zoom on February 15th at the Longmont Lutheran Church. President Vern Raben began the meeting with self-introductions of members attending in person and those on zoom. Nineteen members attended in-person, 19 attended by Zoom.

II. Meeting Presentation

Our guest speaker for the February meeting was Tatsuya Akiba with his presentation "All Good Things Must Come To An END (Eccentric Nuclear Disk)". Tatsuya is an astrophysics Ph.D. candidate (2025) at the University of Colorado Boulder. He currently works with Professor Ann-Marie Madigan on gravitational dynamics of various scales: from planetary systems around white dwarfs to star clusters around super massive black holes. He graduated from Truman State University with B.S. degrees in physics and mathematics before joining CU Boulder. He has been awarded several research awards/fellowships including the Raynor L. Duncombe Student Research Prize and the Dissertation Completion Fellowship (CU Boulder graduate school). He is also passionate about teaching and public outreach; having served as a Lead Graduate Student Fellow for the Center for Teaching and Learning and is currently the instructor for an introductory Python course in the CU Boulder astrophysics department.

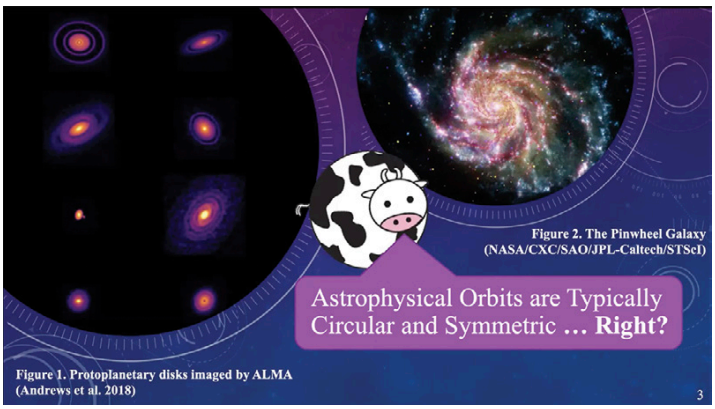
All Good Things Must Come To An END (Eccentric Nuclear Disk)

From humans to super massive black holes, many objects in the universe get a boost or a "kick" from certain phenomena. Super massive black holes (SMBHs) can get a kick by emitting gravitational waves anisotropically - not the same way in every direction - during the merger of two black holes. SMBHs lurk at the center of most galaxies and are usually surrounded by a dense region of stars called a nuclear stellar cluster. When these black holes receive a kick, the surrounding star cluster rearranges itself into a lopsided, eccentric disk. These eccentric disks are fairly abundant in the universe: our neighboring galaxy, Andromeda, hosts an eccentric disk in its nucleus for instance. In this talk, Tatsuya present results from a series of N-body simulations which show the formation and evolution of eccentric disks after a kick gets imparted on the central SMBH. He shows that eccentric disks are able to produce tidal disruption events - which are when stars get ripped apart due to the SMBHs tidal gravity - with extreme efficiency. These tidal disruption events can be used as observational signatures to follow-up future gravitational wave events and to look for these kicked SMBHs.

Introduction

Tatsuya looks at how different astrophysical bodies interact with each other gravitationally. This is usually done by N-Body simulations in which he throws a bunch of particles together that interact with each other through gravity and see what happens. Today we talk about eccentric nuclear disks; with orbits that are eccentric and aligned and how we might dynamically get to such a configuration. Today we will focus on the scale of star clusters in this tight, gravitationally bound environment around SMBH that live in the nucleus of galaxies. He analyzes gravitational dynamics on all scales and these same dynamic mechanisms are applicable to other systems in astrophysics as well. So, how do we get from the circular disk on left to concentric disk on right?

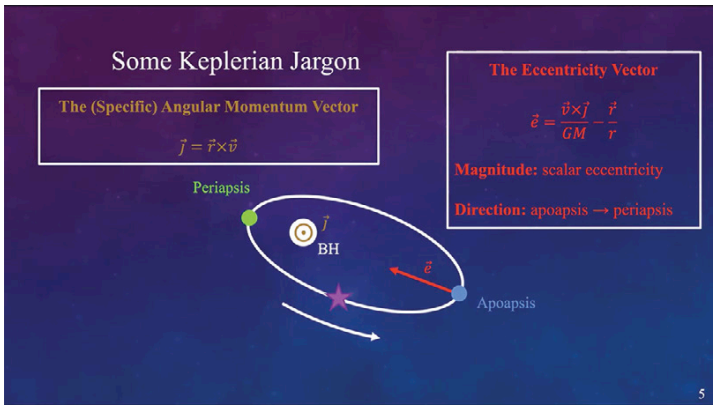
Spherical Cow Analogy – astrophysicists like to imagine and think of things as being spherical, symmetric, circular, easy to deal with. In general, we do typically see a lot of symmetric and circular orbits, so this image usually holds true, but not for all astronomical objects.



Looking at our nearest neighbor, Andromeda, we see it displays an example of asymmetry (not symmetric). Zoomed into the very center where there is a SMBH, regions surrounding we see a weird lopsided area of brightness, this is location of SMBH. Two peaks, fainter one the SMBH about 6 ly away another bright area of stars.

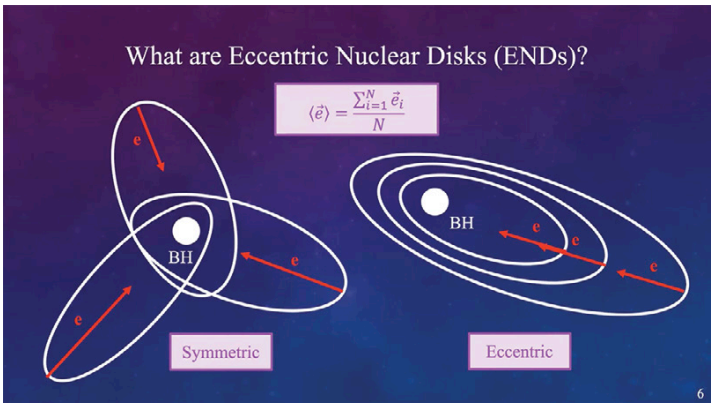
Picture of the Andromeda Galaxy (Evans 2010)
Double Nucleus of Andromeda (Lauer 1993)

Some jargon that dynamacists like use to describe orbits of stars around a Super Massive Black Hole (SMBH):



- Diagram of elliptical orbit of star around a black hole (BH)
- Semi-major axis, half of the length of the long side of the ellipse (purple line)
- Peri-apsis – The point nearest the object being orbited (green dot)
- Apoapsis- the point in an orbit farthest away from the body being orbited (blue dot)
- Angular momentum vector (brown circle)
- Eccentricity tell us how elongated the orbit is
- Eccentricity vector is line between periapsis and apoapsis (red arrow)
- Eccentricity vector tells us vector quantity; that points from periapsis to apoapsis
- This tells us not only how elongated the orbit is in space but also the direction of that elongation in 3D space, so vector quantity is going to be useful for us

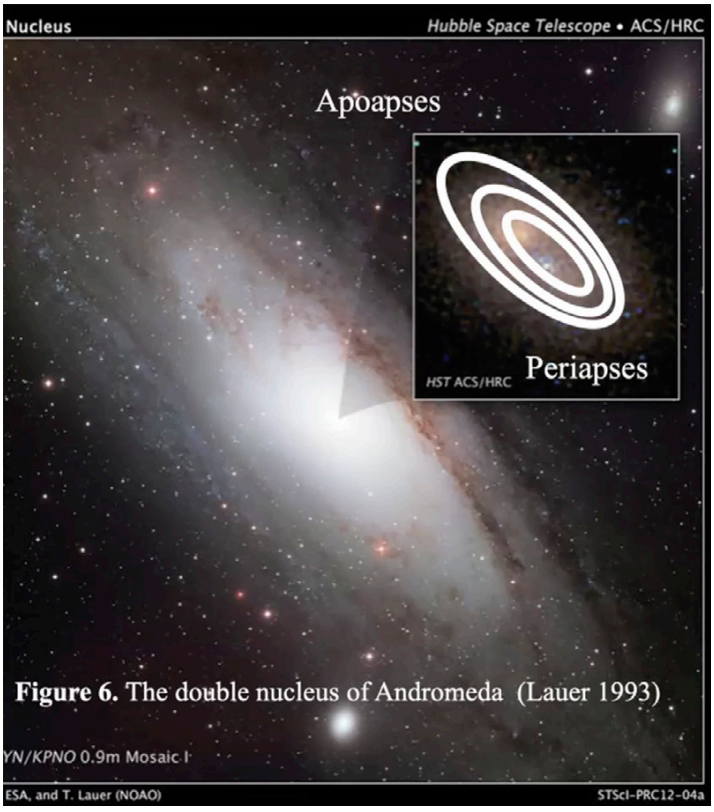
What are Eccentric Nuclear Disks (ENDS)



Eccentric disks are best defined when compared to what we expect in axisymmetric distribution- exhibiting symmetry around an axis
Symmetric

- Could be eccentric orbits but these are randomly scattered in the plane
- Eccentricity vectors will always point in all different directions in 3D space
- Eccentric disk have a collection of periapsis on one side of the disk and of apoapsis on the other side of the disk
- Vector lines all pointing coherently in one direction; have aligned in same direction
- Mean eccentricity vector tells about alignment Mean= ~1 near maximal alignment

Observational Evidence for ENDs



The double nucleus of Andromeda Lauer 1993)

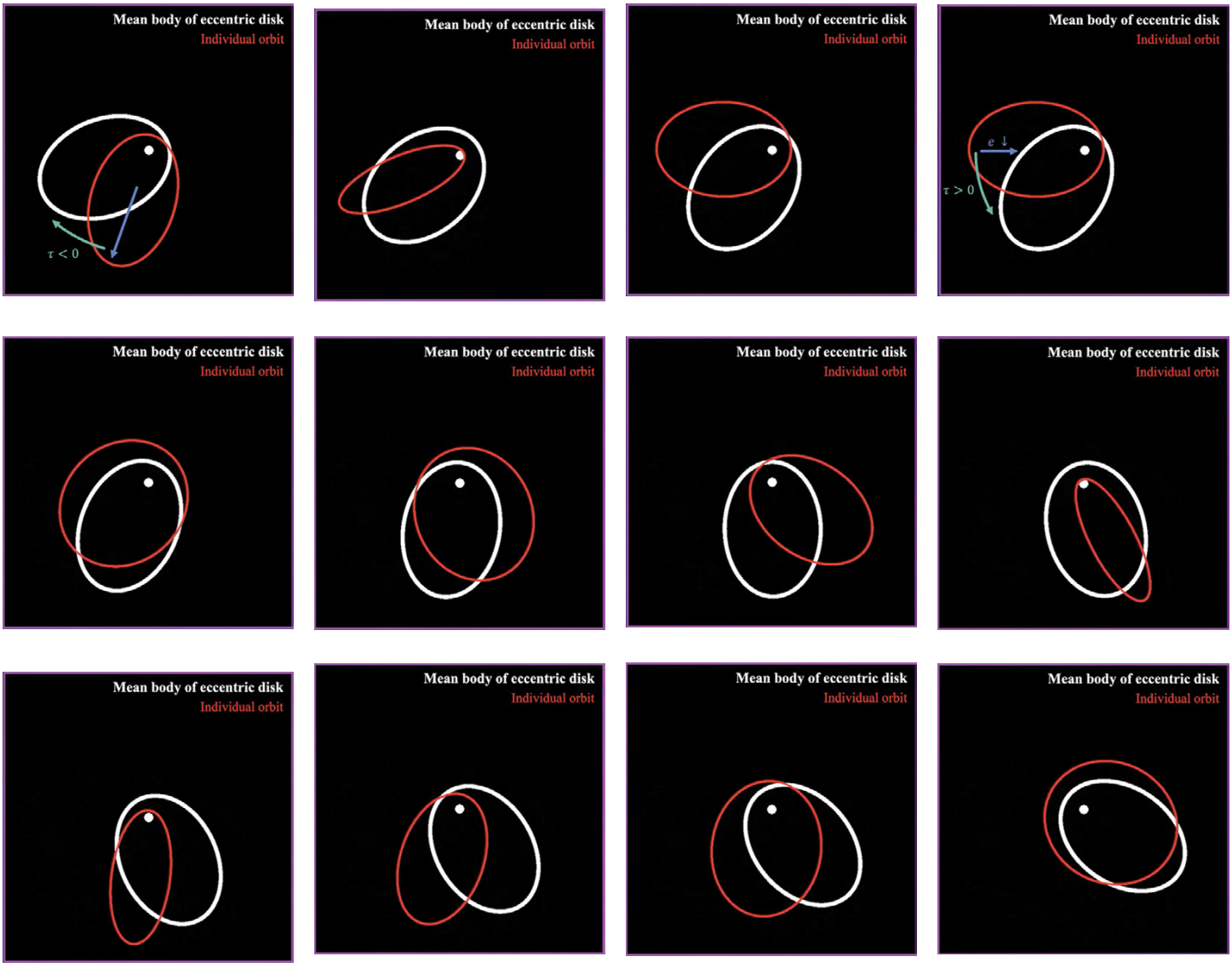
- Zoomed-In image for Andromeda
- Periapsis on one side of the disk and apoapsis in other area of space- get two peaks
- Double nucleus, lopsided distribution well modeled by ENDs, get two peaks because of concentrations of those stars and the alignment of the eccentric vectors
- About 15% of nearby, elliptical, massive galaxies show END features

The END is Stable due to Torques (Madigan + 2018)

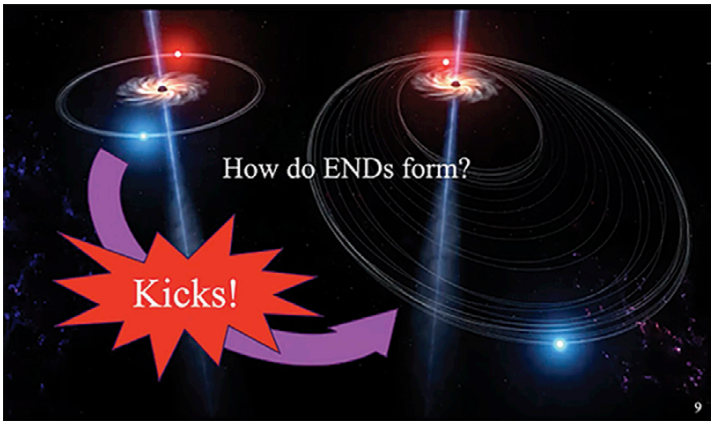
White line – Mean body of eccentric disk (average) Red line – individual orbit

Animation shows oscillating behavior of the orbits in the eccentric disk going a little ahead of the disk then a little behind and getting longer then more circular, then repeats this process.

This is caused by effects of differences in mass due to more concentration of stars near apoapsis, the red orbit feels a torque that brings it back toward the rest of the eccentric disc increasing its eccentricity, slows down, letting the white orbit pass it, as so on, creating an oscillating in eccentricity behavior.

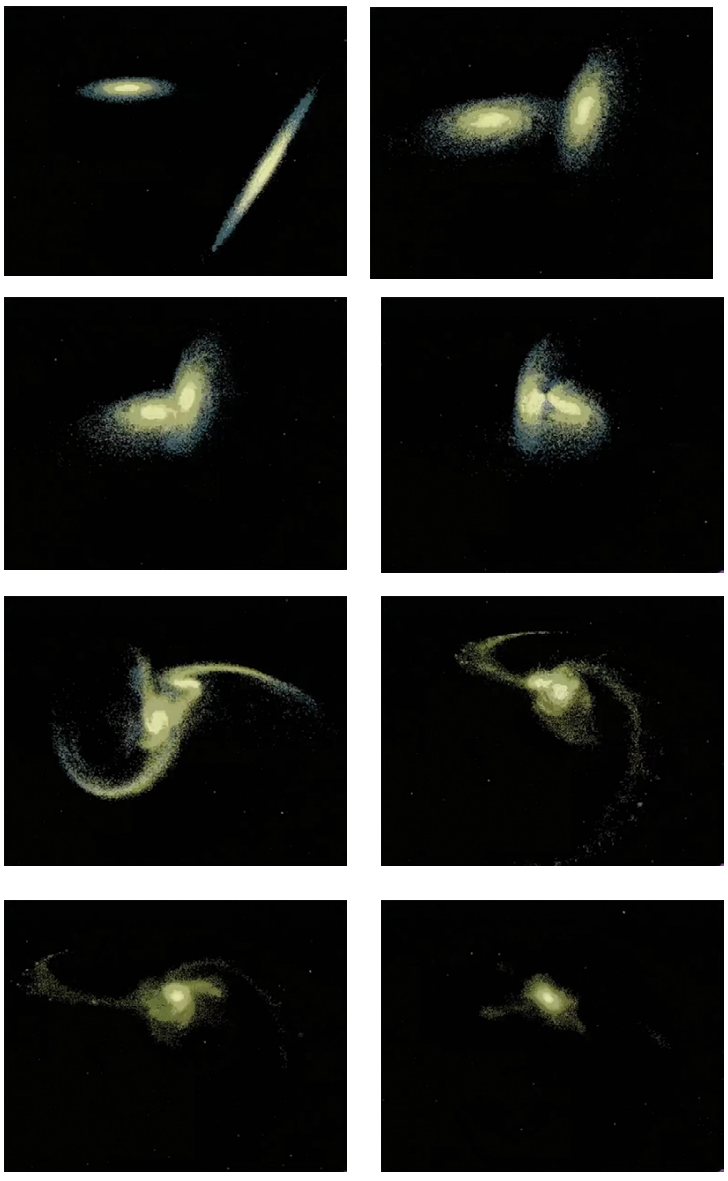


How do ENDS form?
How do we go from circular to elliptical? From KICKS!



Formation mechanism of concentric discs using gravitational wave recoil kick between Super Massive Black Holes (SMBHs).

Spiral Galaxy merger simulation

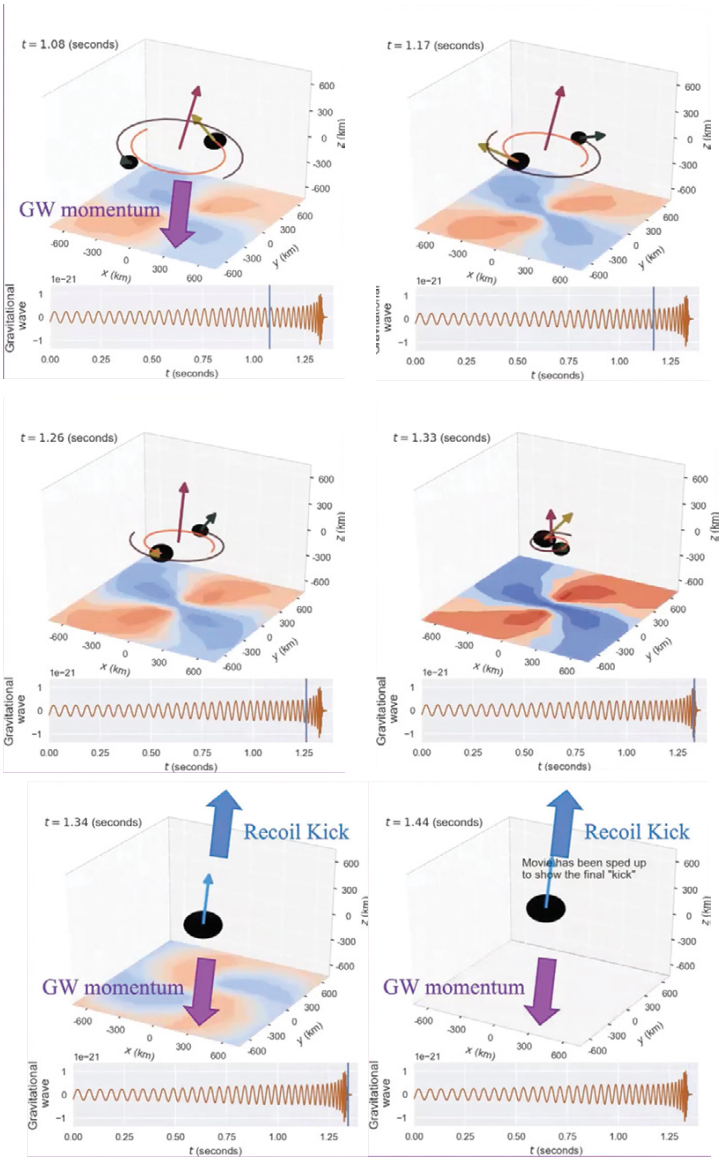


- Galaxy Mergers > Gravitational Waves
- We know that there are SMBHs at centers of massive galaxies
- When two massive galaxies merge, their central SMBHs will also merge, thus a binary system of BHs can form
- The BHs in-spiral and merge; we know that when SMBHs merge they emit gravitational waves – first detected stellar mass black holes in 2015
- Future/ongoing missions to detect SMBHs binary mergers:
- Laser Interferometer Apace Antenna (LISA)
- Pulsar Timing Arrays (PTAs)

Consequence of SMBH merger: Gravitational Wave Recoil Kick

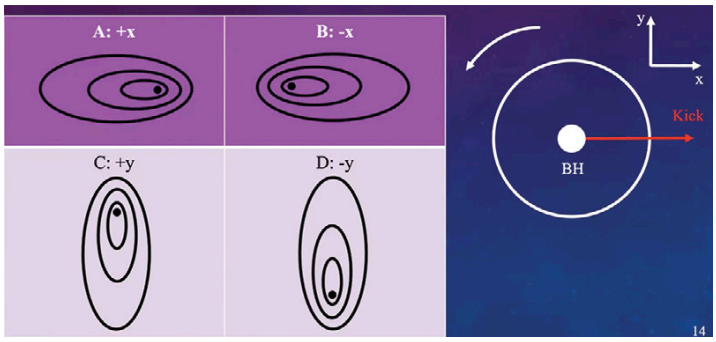
- Two SMBH merging
- Net gravitational wave emission in one direction
- Recoil kick In opposite direction

A gravitation wave recoil kick simulation (Varma 2020)

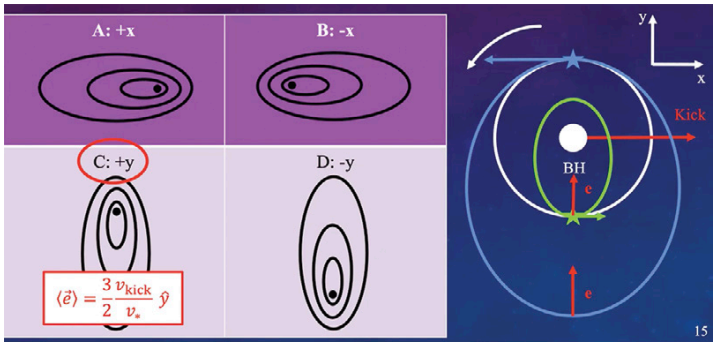


Our work – The Formation Mechanism (Akiba & Madigan 2021)

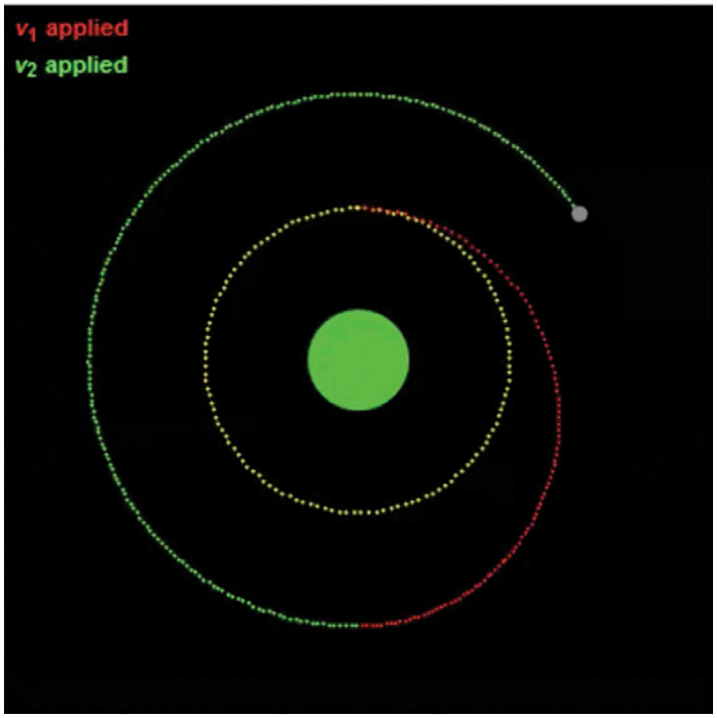
Multiple choice quiz. What is the result of the outcome of kick illustrated on the right – four choices on left



Answer is: C - Recoil forms 90° from the kick



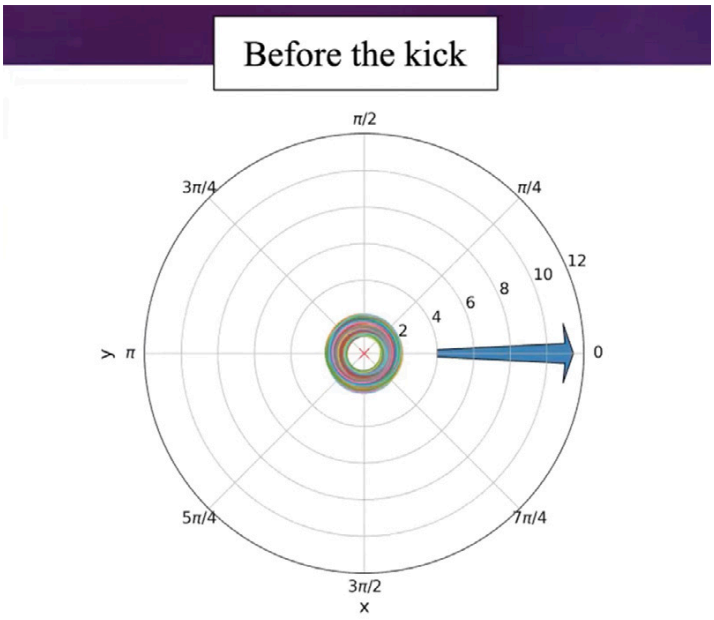
- These dynamics analogy to the Hohmann Transfer Orbit Animation



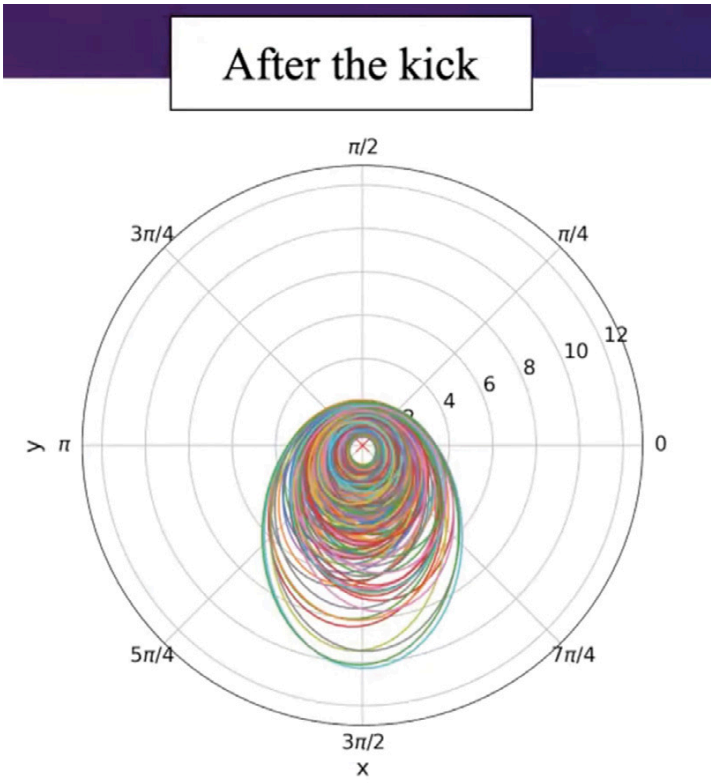
- An orbital maneuver that transfers a satellite from one orbit to another
- Used for space missions to Mars such as the NASA In-Sight probe, most fuel efficient way
- The elliptical transfer orbit is analogous to stellar orbits following a recoil
- Previous papers written by Tatsuya on these topics (Akiba & Madigan 2021, 2023)

N-Body Simulations with REBOUND (Rein & Lui 2012)

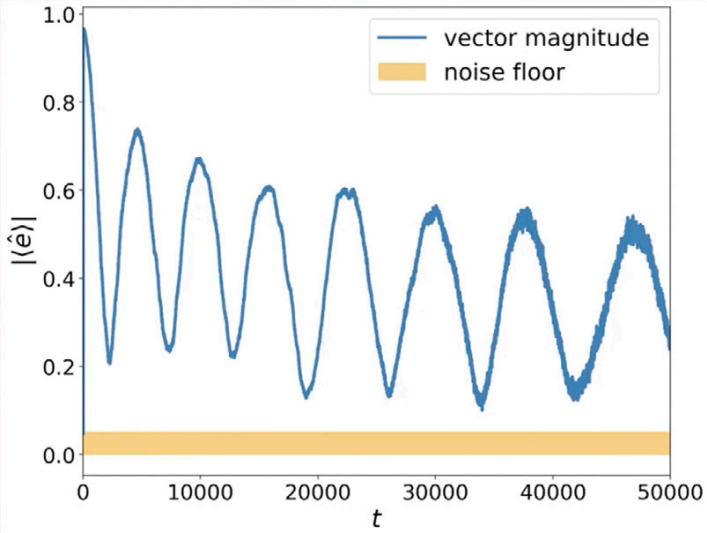
- Formation of an END following the recoil kick (Akiba & Madigan 2021)
- Before the kick



- After the kick in the simulation we see the structure form



Evolution of the Mean Eccentricity Vector in Simulations



- Kick happens at the start – immediately the eccentricity vectors become aligned
- The END is stable over a long time: roughly 75 Myr if we translate this to the Andromeda
- Because of the dynamical stability mechanism, once you kick the BH and the END forms, the END is able to stay together for a long time
- **A kick forms an eccentric nuclear disk**

Exploring the Dynamics of Eccentric Nuclear Disks

Plot of mean eccentricity vector as a function of radius for various kick strengths

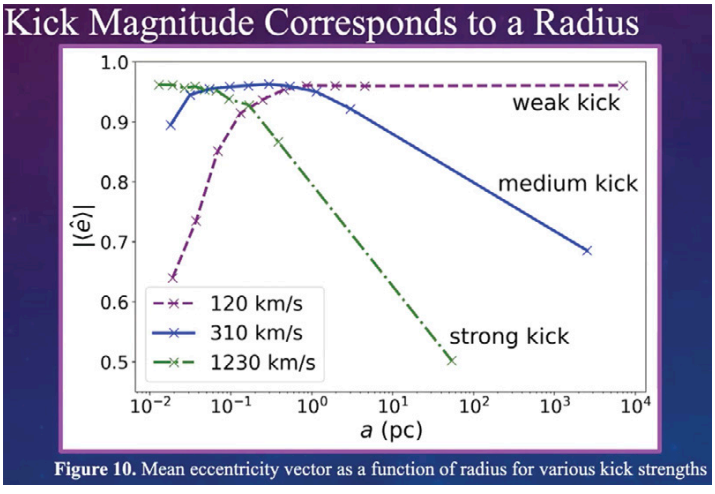
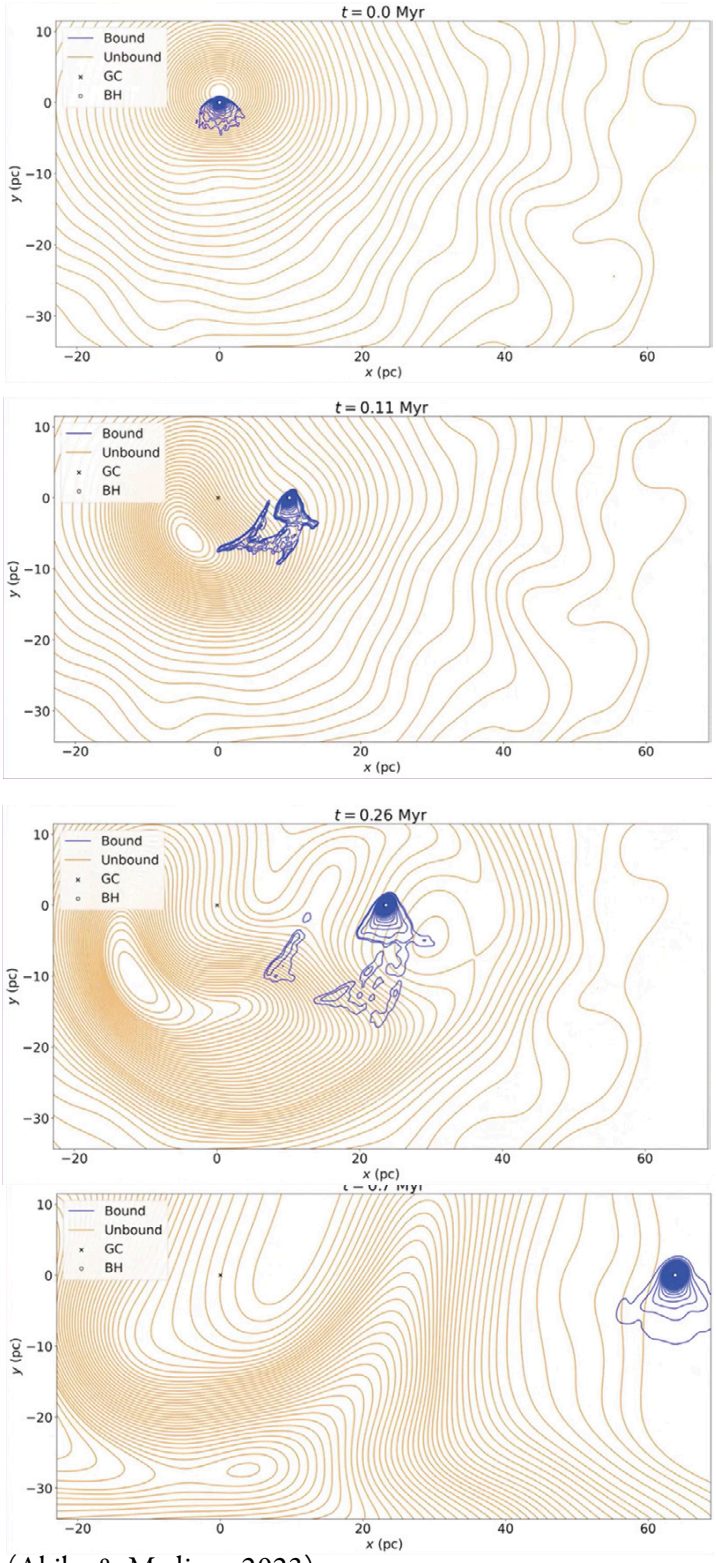


Figure 10. Mean eccentricity vector as a function of radius for various kick strengths

Kick magnitude corresponds to a certain radius of the star cluster that is most effected by a kick of a certain magnitude

- X-axis - spatial scale in units of parsecs (~3 light years
- Y-axis- mean eccentricity vector
- Plot three lines of weak, medium and strong kicks
- If the kick is stronger; ejects most of the stars bounded to it, END more tightly bound, strong kick forms END closer in, medium kick somewhere in between, weak kick forms END much farther out in the stellar cluster
- A very strong kick is on the order of escape velocity for a galaxy so will get a SMBH completely ejected from the galaxy

Surface Density following an In-plane Kick



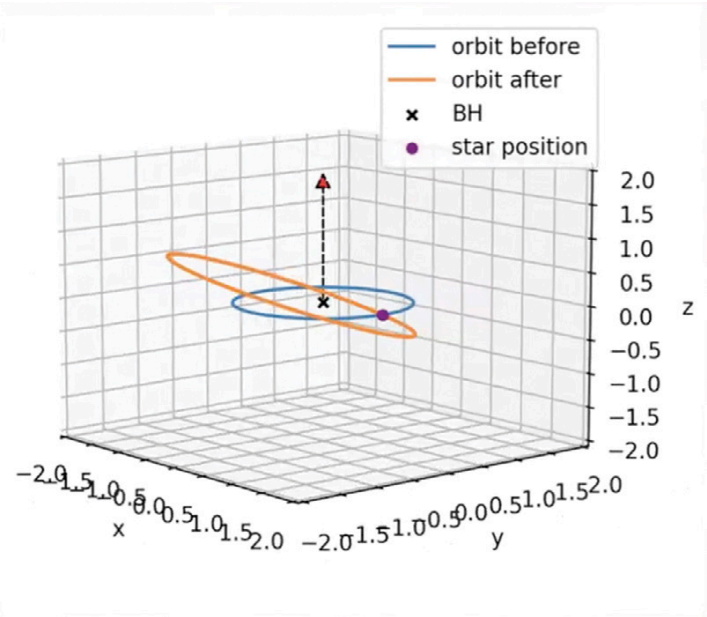
(Akiba & Madigan 2023)

Surface Density maps face-on following an in-plane kick

- GC = Galactic Center, BH = Black Hole, X = Center of star cluster where BH was
- Concentration of stars- Blue is bound stars, Brown is unbound stars
- When the kick happens can see blue bound cluster form END 90° away from kick, flying out of the center of the galaxy
- Going to get a Recoiling SMBH with an END of stars around it

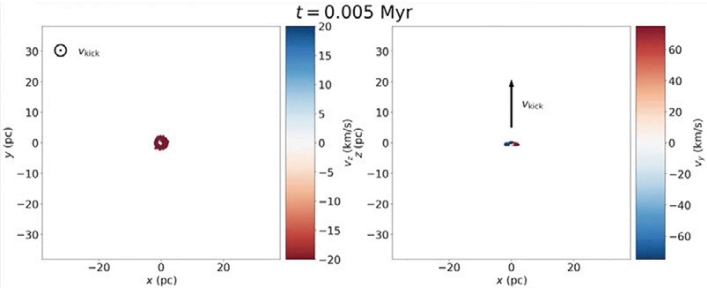
What about Out-of-plane Kicks?

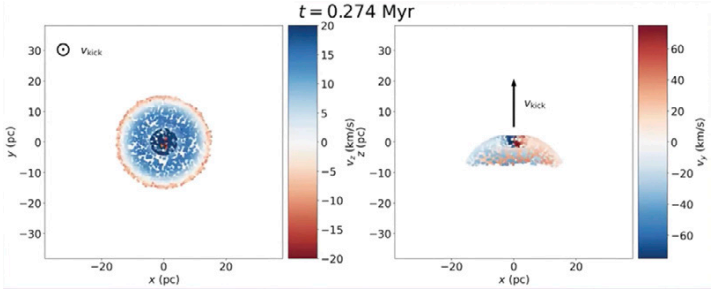
3D Animation Illustrates Orbits before and after an out-of-plane kick (Akiba & Madigan 2023)

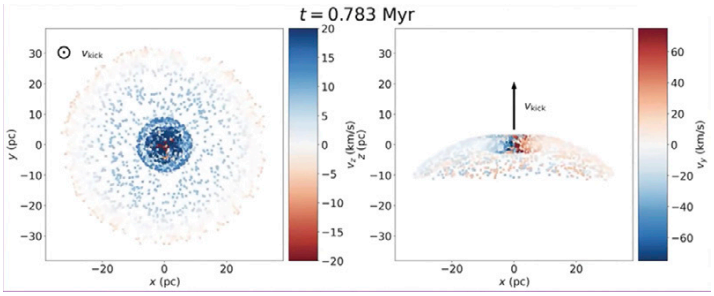


- Kick happens in the out-of-plane place
- Star orbiting around SMBH gets a kick in positive z direction
- Blue= orbit before Orange=orbit after
- Depending on where star is located with respect to BH at beginning, get a tilt 90° away from that position and get eccentricity developing in the direction of the position of the star in the beginning

Line-of-sight Velocity for Out-of-plane Kicks

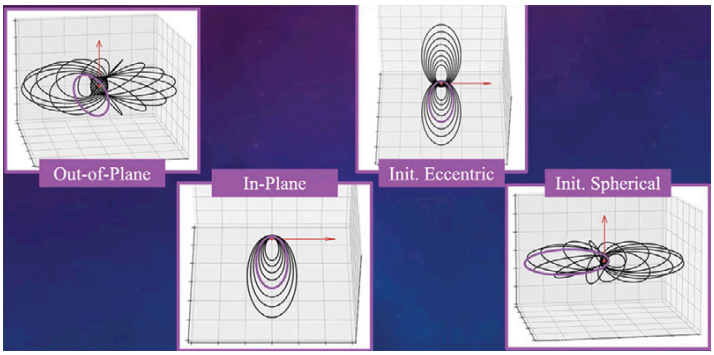






- One of big observables in term of trying to look for these SMBH is line-of-sight velocity which can be detected from doppler shifts
- Red is red-shifted=stars moving away, blue is blue shifted- stars coming towards
- These are potentially observable around a SMBH
- Get rings of blue shifted and red shifted material this is something we can observe after a gravitational wave signal is detected

Wonderfully complex dynamic structures after a Kick!



- Many different dynamic complex structures can form after a kick
- Out-of-plane, In-Plane, Init. Eccentric, Init. Spherical
- Question is how do these systems evolve over time and do they have any observable signature as a follow-up to gravitational wave signals we might observe in the future?
- Recap: ENDs might be more common than spherical cows; ENDs form when a circular disk suffers an in-plane gravitational wave recoil kick; interesting dynamics for effectively every configuration imaginable when we kick a SMBH

Tidal Disruption Events (TDEs) - Black holes ripping stars apart

When a star comes too close to the black hole the stars gravity is not strong enough to hold together and it is ripped apart. Stellar debris forms an accretion disk and emits a luminous flare (Phinney 1989) This is useful for: detection of black hole, (Maksym + 2013), accretion physics (Zauderer+ 2011, and stellar dynamics (Naoz 2016, Madigan + 2018)

Enhanced Rates are observed in Merging Galaxies

TDEs do not happen at the same rate in all galaxies and are preferentially found in:

- Post-starburst galaxies – lots of young stars but no active star formation> post merger
- Ultra-Luminous Infrared Galaxies (ULIRGs) – thought to be an active ongoing gas-rich galaxy merger

Takeaway: When galaxies merge it seems to increase the rate these stars are ripped apart: Do ENDS have anything to do with this?

Detecting TDEs in Simulations

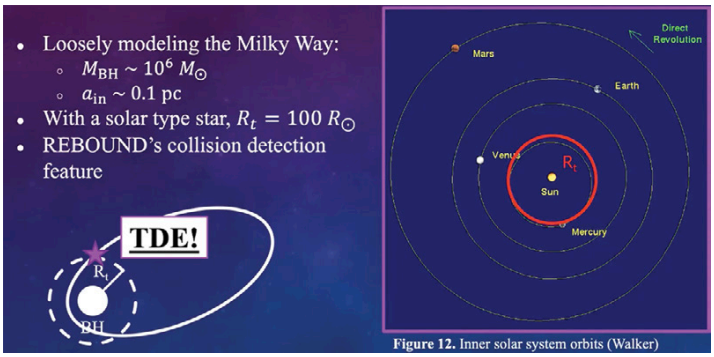
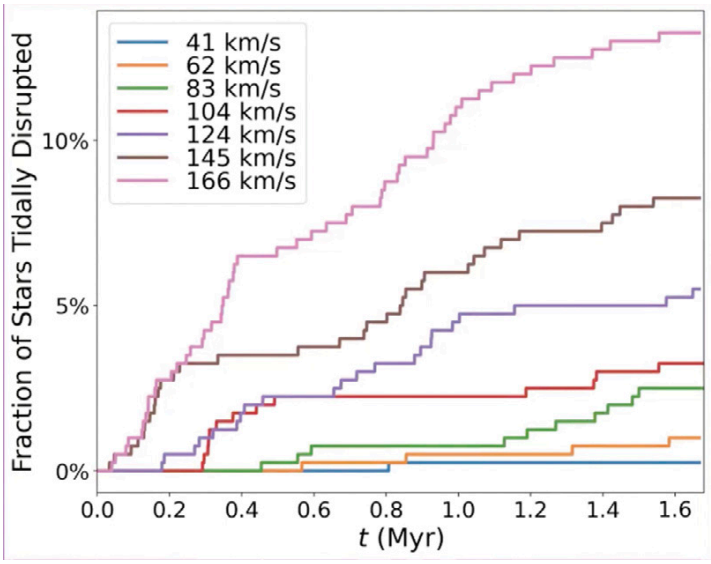


Figure 12. Inner solar system orbits (Walker)

- Develop black hole radius = if star inside of will get ripped apart
- For spatial scale, plot of inner solar system orbits, imaging BH where the Sun is
- Tidal disruption radius (red circle) would be around the orbit of Mercury
- Orbits have to be very eccentric in order to get close enough

Tidal Disruption Rates in Our Simulations



Comparison of the tidal disruption rates between simulations of varying kick magnitudes (Akiba & Madigan 2024; in-prep)

- x-axis= time y-axis= fraction of stars that get disrupted
- Tidal disruption rates high = 3-4 order of mag. higher than symmetric configurations
- Consistent with rates in merging galaxies (Tadhunter+ 2017)

Extreme Eccentricity Oscillations

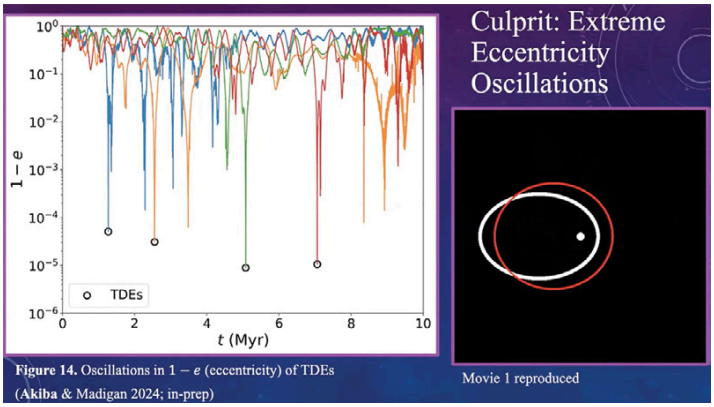


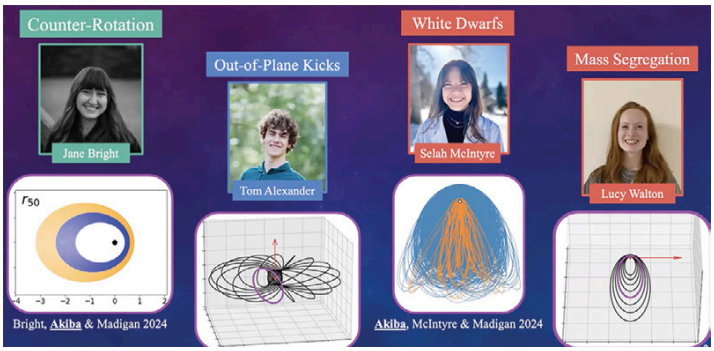
Figure 14. Oscillations in $1 - e$ (eccentricity) of TDEs (**Akiba** & Madigan 2024; in-prep)

- torque of ENDs create extreme eccentricity oscillation
- gaining more eccentricity; then becoming more circular
- this sort of torque so strong – get extreme oscillations of eccentricity
- X axis= time Y axis= 1- eccentricity
- Top= circular orbits; Bottom= very eccentric orbits
- Get high spikes of eccentricity due to ENDs force (circled)

Concluding takeaways:

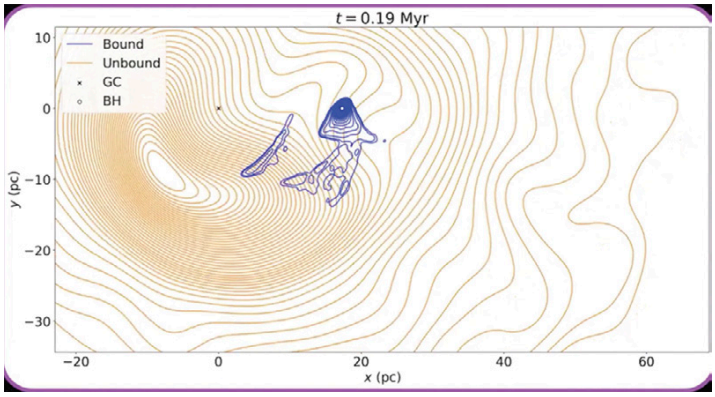
- ENDS are likely common in the universe
- ENDS are stable
- Circular disk of stars + in-plane gravitational wave recoil kick forms a stable END
- Kicks completely out-of-plane cause coherent tilting
- ENDs host tidal disruption rates as high as 0.1 – 1yr-1 (very high rate) 1 star getting ripped apart every year to every ten years

Other Researchers working with Tatsayu and others on related areas:



- Jane Bright – working on ENDs with counter rotation
- Tom Alexander – advance high school student – long term evolution of out-of-plane kick
- Selah McIntyre – undergrad working with Tatsayu – create ENDs around white dwarfs
- Lucy Walton – what happens with different population of masses in our systems

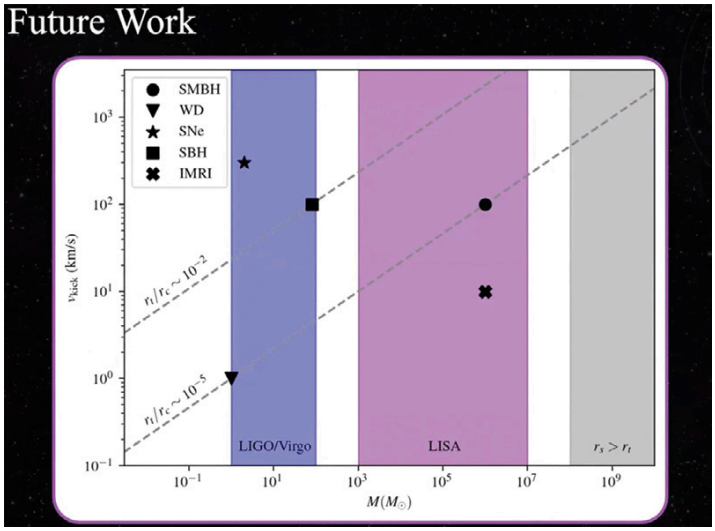
Future Work of Tatsayu Akiba



We get to preview some exciting work that Tatsaya and others continue to work on. Again we see the animation of the SMBH flying out of the galaxy. If the kick magnitude is high enough that a SMBH is completely gone - ejected out of the galaxy - it is really very hard to see that SMBH that is now "lurking in the middle of nowhere". So they are working on observational signatures for those SMBHs that are not a part of a galaxy anymore because they got kicked out of it. They are working on this in different ways:

- One is that by looking at this density profile we might actually be able to see the eccentric nuclear disk directly because stars are bright
- An avenue being explored is (TDEs); when a star gets ripped apart, an accretion disk forms and is really bright and can be seen: may be one way we can detect these SMBHs

Work on astrodynamics kicks: Plot showing a lot of the different kicks that exist in astrophysics



- X-axis – mass of object being kicked; y-axis – magnitude of kick that is expected
- We are starting to populate this plot with a bunch of astrodynamical kicks that exist in nature and trying to uncover the dynamics surrounding them

Tatsayu Akiba's presentation was followed by discussion and questions from members:
The rates of TDEs - is that per galaxy? So this starts with Black Holes combining to create a kick, that sends out the gravitational waves, that we hope to be able to detect as some point, do we have enough directionality from that to start looking at certain areas for these red/blue shifts of the results of these tidal events? As far as the observational evidence, how far away can a galaxy be and still be able to observe ENDs? What wavelengths are you looking at to see these events? At what point in galaxy formation would ENDs happen? Is this in every galaxy? Is the size of the galaxy related to the number of ENDs? What are some of the events that create a big enough kick to get rid of a black hole? Most kicks are created by two super massive black holes merging? What happens when two black holes of equal mass merge, how does that fit into spectrum of work that you have? So the kick is really a phenomena more related to the gravitational waves rather than how the mass is perturbing the disks directly around them?

See the full meeting video recording at https://members.longmontastro.org/

III. Business Meeting

- Treasures Report – By Bruce Lamoreaux

Insert business report (See page 21)

- Old/New Business/Upcoming Events
  - 2024 Rabbit Mountain Star Parties- Star Parties Scheduled by Bill Tschumy, Outreach Coordinator, with Boulder Parks and Open Space (Ranger talk starts about half hour before times noted below)
  - March 15th @ 7:30 PM – One day before First Quarter Moon
  - April 12th @ 8:30 PM – Crescent Moon
  - May 3rd @ 8:30 PM – No Moon
  - June 7th @ 9:00 PM – Very thin crescent Moon (one day after new)
  - July 12th @ 9:00 PM – First Quarter Moon
  - August 2nd @ 8:30 PM - No Moon (two days before New Moon)
  - September 6th @ 8:00 PM - Crescent Moon
  - October 4th @ 7:00 PM – Two day old Crescent Moon
  - November 1st @6:30 – New Moon

Bill has arranged with BPOS for the addition of two new monthly LAS star parties to the schedule this year, March 15th and November 1st. Feel free to come out to Rabbit Mountain, (east of Lyons off Hwy. 66) even if you do not have a telescope, come on out and look through the telescopes, talk to people about what they are seeing, or just have some fun.

Solar Eclipse Event Planned for Louisville – April 8, 2024
Louisville has asked once again for us to come out for an Solar Eclipse viewing. If you can come out and have a scope with solar filter bring it along or just come out for fun.

Sandstone Star Party Event March 29th at Sandstone Ranch, need telescope volunteers for this also, set up in upper parking lot. More information coming soon.

Business Report by Bruce Lamoreaux

Longmont Astronomical Society

P.O. Box 806
Longmont, CO 80502-0806

LAS Treasurer's Report - Bruce Lamoreaux **2/15/2024**

Main Checking Account (xxx-1587)

Begin Balance:	$ 9,300.00	**1/4/2024**	
Deposits:	$ 650.00	Membership, Magazine	
Expenses:	$ (515.00)	Bank Charges, Calendars, Magazine	
Current Balance:	**$ 9,435.00**	**2/2/2024**	

2-Year Savings Account (xxx-1478) (matures 10/23/23)

Past Balance:	$ 8,200.00	**10/23/2023**
Interest:	$ -	
Balance:	**$ 8,200.00**	**12/29/2023**

Telescope Fund (xxx-0165)

Past Balance:	$ 1,100.00	**12/28/2023**
Deposits:	$ -	
Expenses:	$ -	
Balance	**$ 1,100.00**	**1/30/2024**

Petty Cash

Past Balance:	$ 50.00
Deposits:	$ -
Expenses:	$ -
Balance	**$ 50.00**

Total Assets	**$ 18,785.00**	$18,680.00	$ 105.00	Up from January

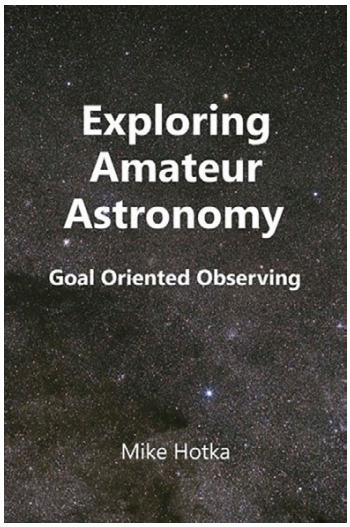
Active Membership:	**96**
Student Membership:	**0**
Total	**96**

"Astronomical League has it All" by Mike Hotka

Over the past few months, I have shared my observing process with you. This process is what I use today to plan, execute and record my observing outings.

A simple way to get started observing is to find a pre-made list of objects to observe and then, one by one, check the objects you observe off this list. A wonderful place to find list after list of astronomical objects to observe is from the Astronomical League's Observing Programs website. Another resource from their website is this PDF File that has these Observing Programs ranked in various ways.

If you have not completed the Messier Observing Program, I would suggest you start with this one first. Also consider the Constellation Hunter Observing Program because this will teach you the constellations and their extent across the sky.



I had planned on several more articles, devoting each month to an Astronomical League Observing Program. These monthly articles are already explained in greater detail in my book, Exploring Amateur Astronomy : Goal Oriented Observing, published by Amazon Publishing, than I could have written in the monthly articles.

The beginning of this book gives more details of the information I shared with you these past few months in the articles. This is followed by a chapter devoted to each Astronomical League Observing Program I completed at the time this book was published in August, 2018. These chapters illustrate the tips and tricks I learned to overcome some of these Observing Programs' steep learning curve before you could record an observation. By reading each chapter of an Observing Program you are interested in starting, you will benefit from what I found worked and will allow you to record observations on your first outing.

Another great resource are all my observations, for each Observing Program I finished, that is on my website. By clicking the links in the Observations columns for an Observing Program, you can see the words and format I used to record the observations for each Observing Program. I would then submit this Observations URL page to the Observing Program's coordinator for their review.

Finally, you can always reach out to me via my email address (mhotka@yahoo.com) to discuss anything astronomical with me, especially these Astronomical League Observing Programs. I can help you pick an Observing Program to start based on your interests. I can help you with techniques I have found successful if you get stuck on a particular Observing Program. Please never hesitate to contact me with questions. I will help to the best of my ability.

My goal with writing these articles for you, is to get you out, observing with your equipment, enjoying the night sky and seeing all the wonders of the universe with your own eyes.

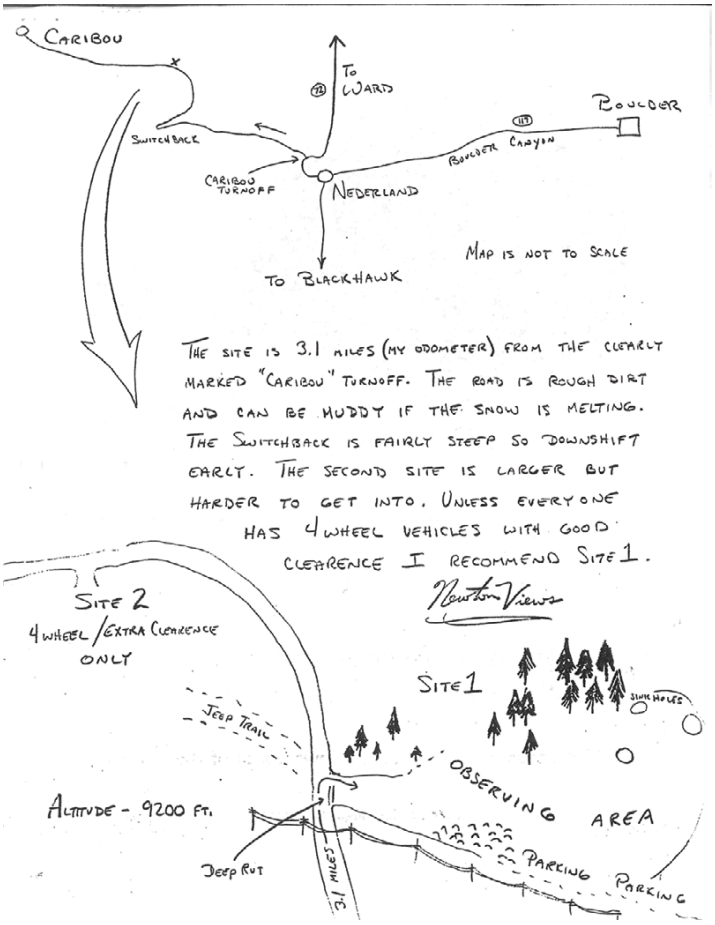
Newsletter Archives by Eileen Hall-McKim

30 Years Ago 1994

The new LAS telescopes were on display at meeting. The club made 10" f/5.6 Dobsonian was present as was the new 10" f/8 Cave Newtonian with clock drives, etc. Both telescopes are in excellent operating condition and the officers will develop a method for member check out of the telescopes.

Steve Kramer gave a presentation on some new HST photographs. Brian Kimball showed some lunar eclipse photos from November. Bob Ross gave a demonstration of some astronomical software running on a NEC laptop.

New Moon Star Party April 9, at new observing site near Caribou, Colorado; see map below:



20 Years Ago 2004

"Astronomy Night" at Lyons Elementary. This evening for students and parents is on Friday, April 16th, probably about 7:30pm-9:30pm. The school is quite excited about giving students a first look at the astronomical sky.

Sun, Skies and Girl Scouts Red Feathers Lake, June 12th and 13th. I am putting on a weekend event at Magic Sky Ranch, near Red Feathers Lake, June 12 and 13. It's called "Sun, Skies and Girl Scouts". The girls (ages 11-16) will be learning about the Sun-Earth Connection. They will be doing all sorts of hands on activities during the day, including the Herschel experiment. At night, they will be making a star chart and observing the skies. I was hoping that members of the LAS would be interested in coming out to help at night (and perhaps even bring a few telescopes). Of course, if anyone is interested in participating for the daytime activities, they would be welcome. Please let me know if interested in helping. Ms. Jill Pommrehn.

Mike Hotka on recording observations: "To record or not to record, that is NOT the question. The question is what should I record? You can never write down too much while at the eyepiece. You can always edit your notes when you transpose them, but I have never done this. I have always saved my initial impressions of the object in my permanent log. I am now adding simple sketches to my notes. I find this very helpful in my squeezing the most detail out of an object that my eye can detect. Whatever you record something. It will be a lasting impression of your time under the stars."

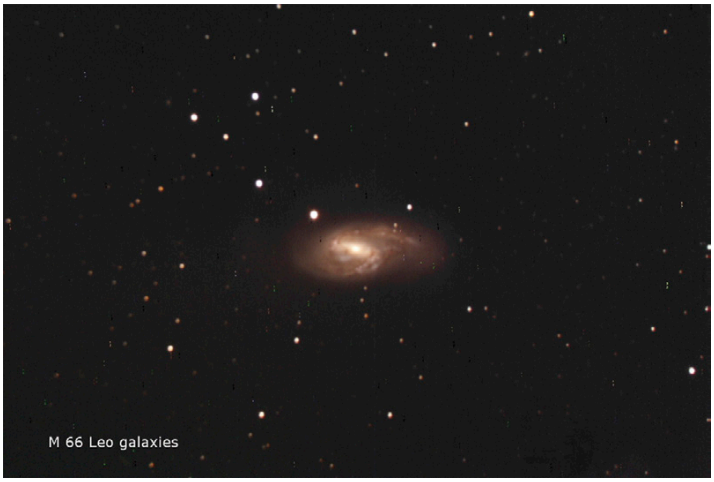
Gary Garzone and his new 30 inch Astrosystems scope

10 Years Ago 2014

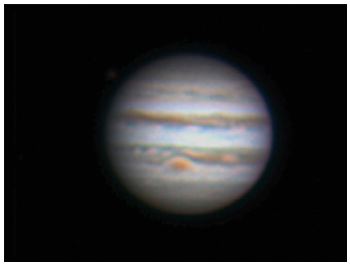
The February meeting was at the IHOP Restaurant in Longmont. Gary Garzone gave a presentation on the constellation Coma Berenices and some of the objects within it. He also gave a short talk about constructions of his home observatory.
There was a discussion about possible dark sky observing at Red Feather Lakes.
LAS has signed an agreement with the Astronomical League to lease their C14 telescope. Wayne Green will drive to Kansas City, MO and pick it up sometime this month.

Since a total eclipse of the moon occurs on night of April 14/15, we've applied for a permit from city. The partial eclipse begins at 11:57 pm MDT, totality begins at 1:56 am and ends at 2:25 am MDT. Scopes and volunteers will be needed!

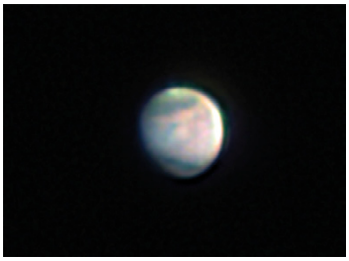
COSMOS – A Space Time Odyssey premiers Sunday March 9, on Local Fox Channel and also airs on National Geographic cable channel.



M 66 Galaxy in Leo by Gary Garzone, Mar 2014



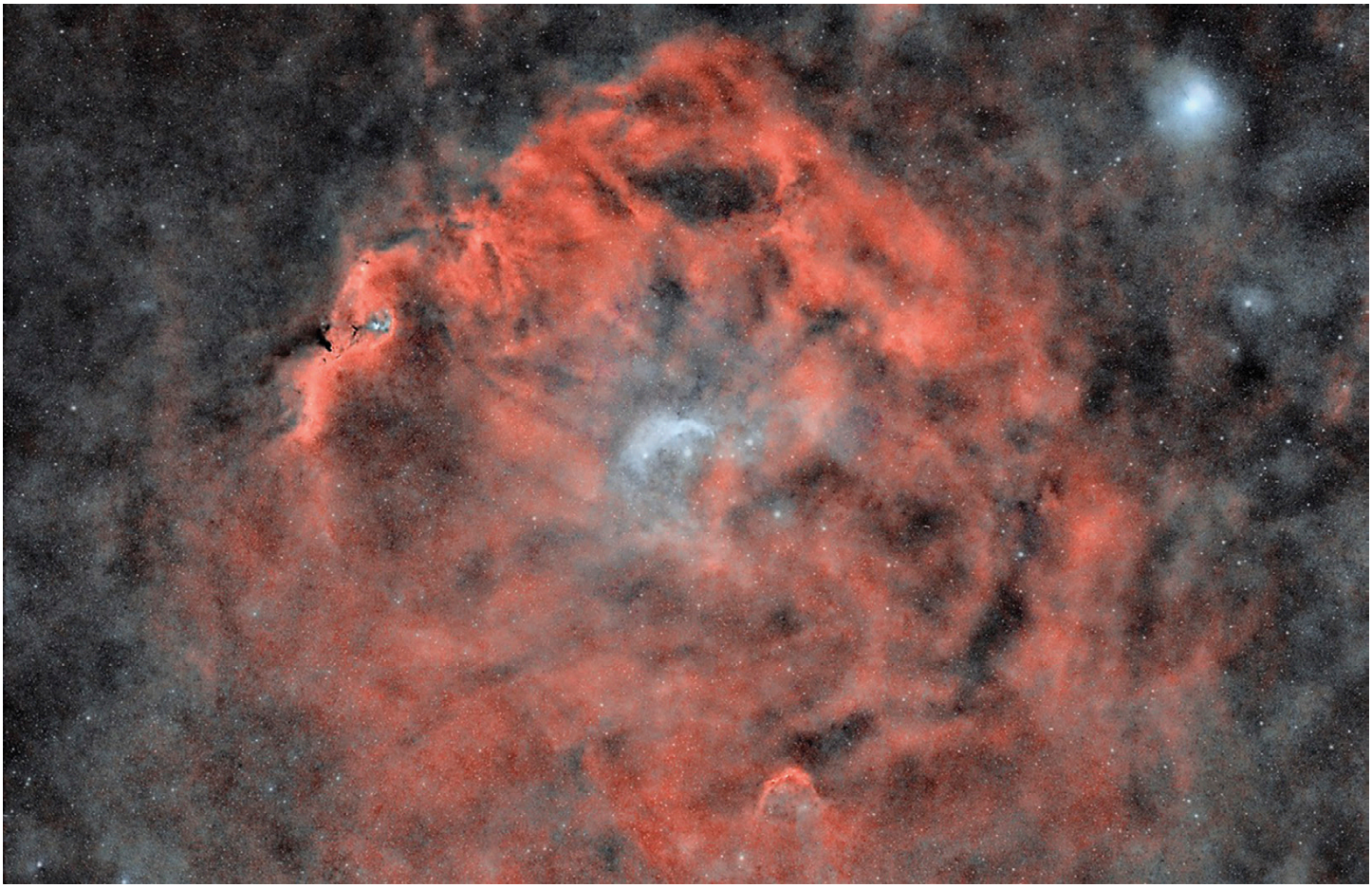
Jupiter Mar 3, 2014
by Vern Raben



Mars Apr 22, 2012
by Vern Raben

Horsehead Nebula by Gary Garzone. Mar 2014

Selection of LAS Member Images in February 2024

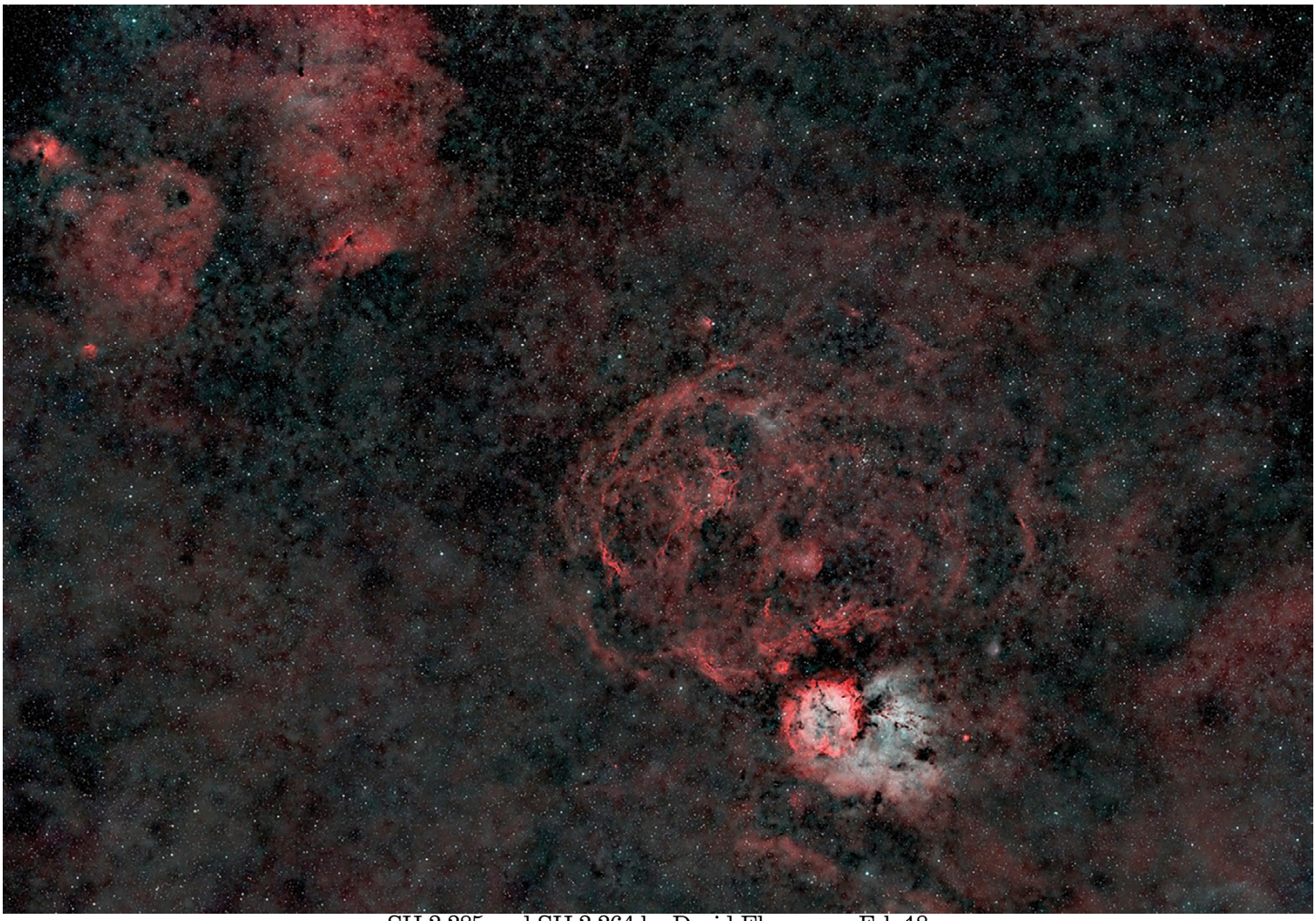


SH 2-264, "Angel Fish" Nebula by David Elmore on Feb 14, 2024

The Angelfish Nebula, Sh2-264. It is the head of the constellation Orion located about 1400 light years distant in the Milky Way. It is part of the giant Orion Molecular Cloud where new stars are being formed and it glows mostly from hydrogen atoms excited by ultra-violet radiation from the hot blue star in the center, Meissa and others.

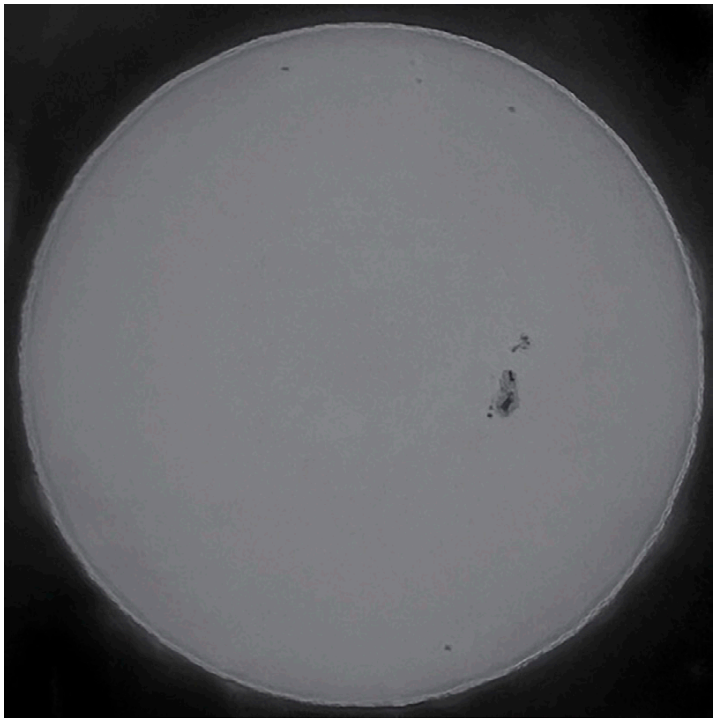
This is very wide field, nearly 10° recorded in narrow band light. Hydrogen-alpha and Hydrogen-beta are red. Oxygen III is teal, Sulfur II is equal parts red, green, and blue. Total exposure time a mere 2 hours 30 minutes using a Borg55FL telescope, ASI2400MC camera, and Antlia dual band filters. From my little observatory at Dark Sky New Mexico.

Processing in PixInsight utilizing starXTerminator, blurXTerminator, noiseXTerminator, and HDRMT. 10% stars added back during non-linear processing. More color tweeks in MacOS Photos.



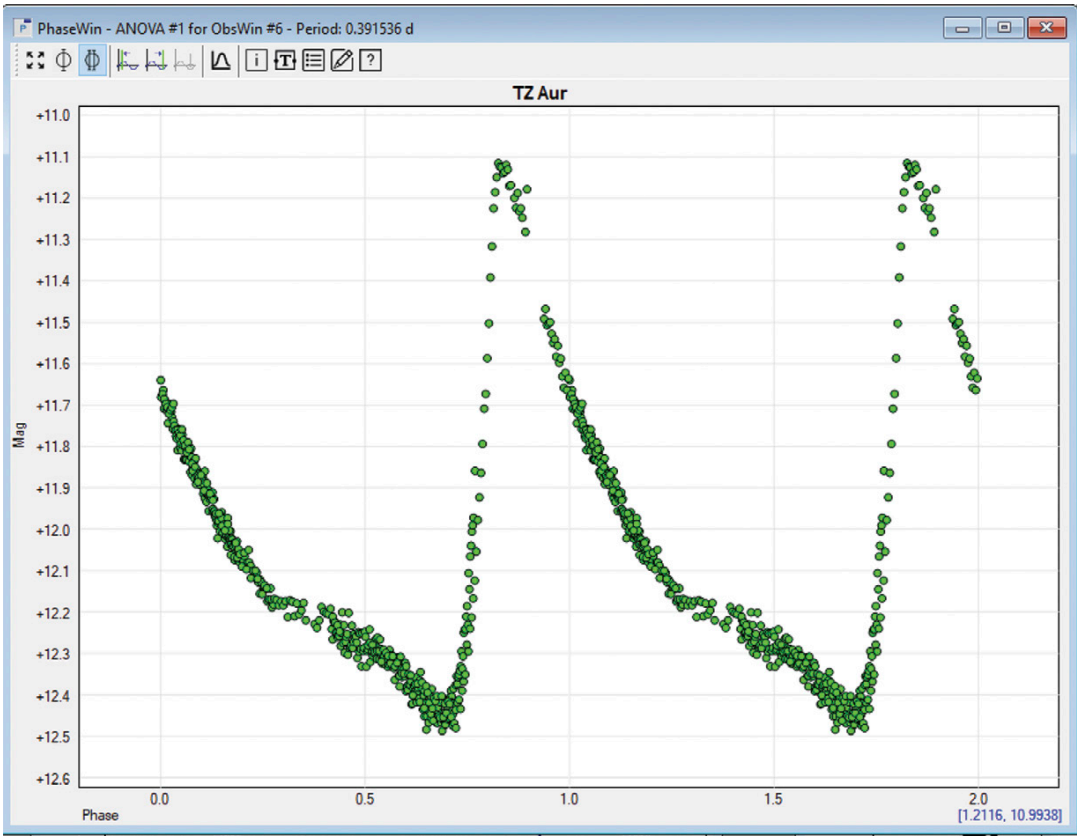
SH 2-285 and SH 2-264 by David Elmore on Feb 18

Sh2-285 is the tiny feature just above center. There are a couple of other Sharpless objects in the field, notably Sh2-264 below center glowing brightly in Hydrogen-alpha (red) with a lot of Oxygen III to the side (teal). What was unexpected is the large feature in the center called G213.0-0.6 that looks like a super nova remnant.



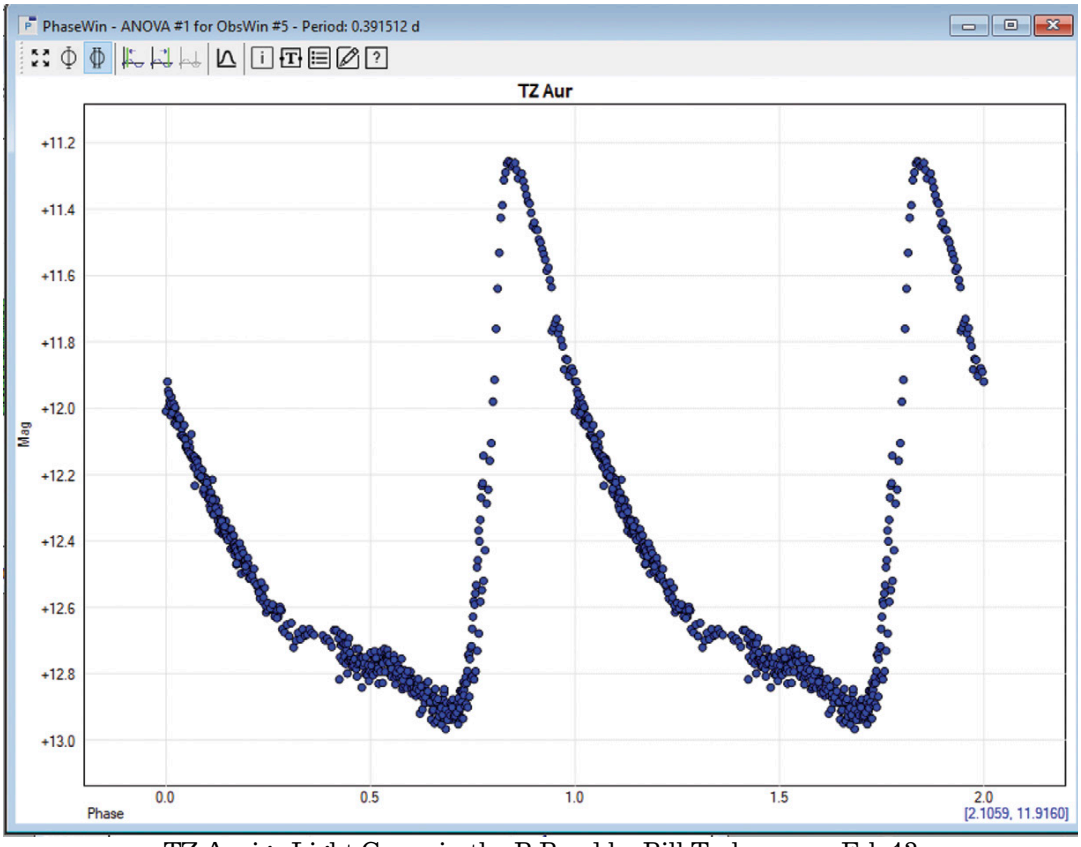
Sunspot AR13590 on Feb 25 by David Elmore

David set up one of his scopes with a solar filter to view a large sunspot on February 25 (NOAA Active Region #13590). About 20 of his neighbors stopped by for a view.

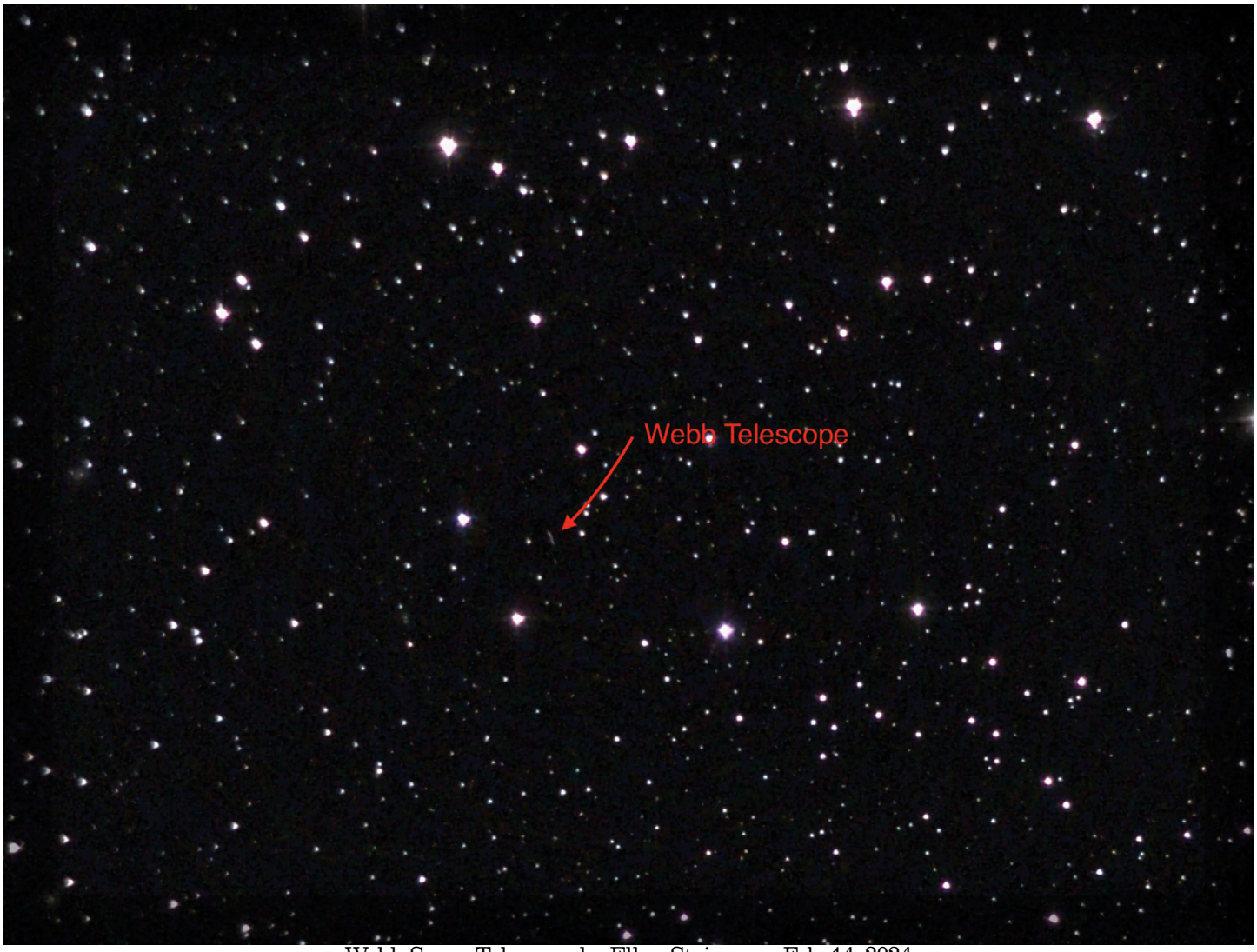


TZ Auriga Light Curve in the V-Band by Bill Tschumy on Feb 13

Bill has gotten back to doing some variable star photometry. He has been working with TZ Aur an RR Lyrid-type variable star in constellation Auriga. RR Lyrids are all short period variables. TZ Aur has a period of 0.391536 days (9.39 hours). He was trying to catch observations throughout its period to make a complete light curve. It took him 5 different nights to get the complete curve.

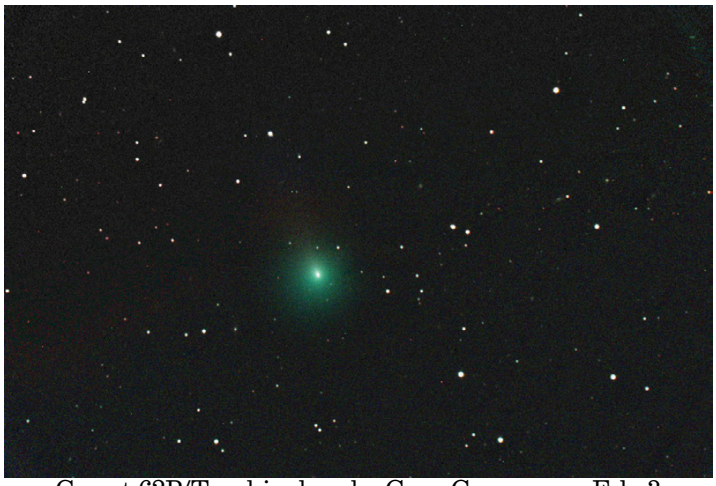


TZ Auriga Light Curve in the B-Band by Bill Tschumy on Feb 13



Webb Space Telescope by Ellen Steiner on Feb. 14. 2024

Ellen took the above picture of the Webb telescope using a "wide field" telescope and then zoomed-in. The Webb Space Telescope is currently in constellation Gemini; the streak is due to its orbit around the L2 point over a 20 minute exposure.

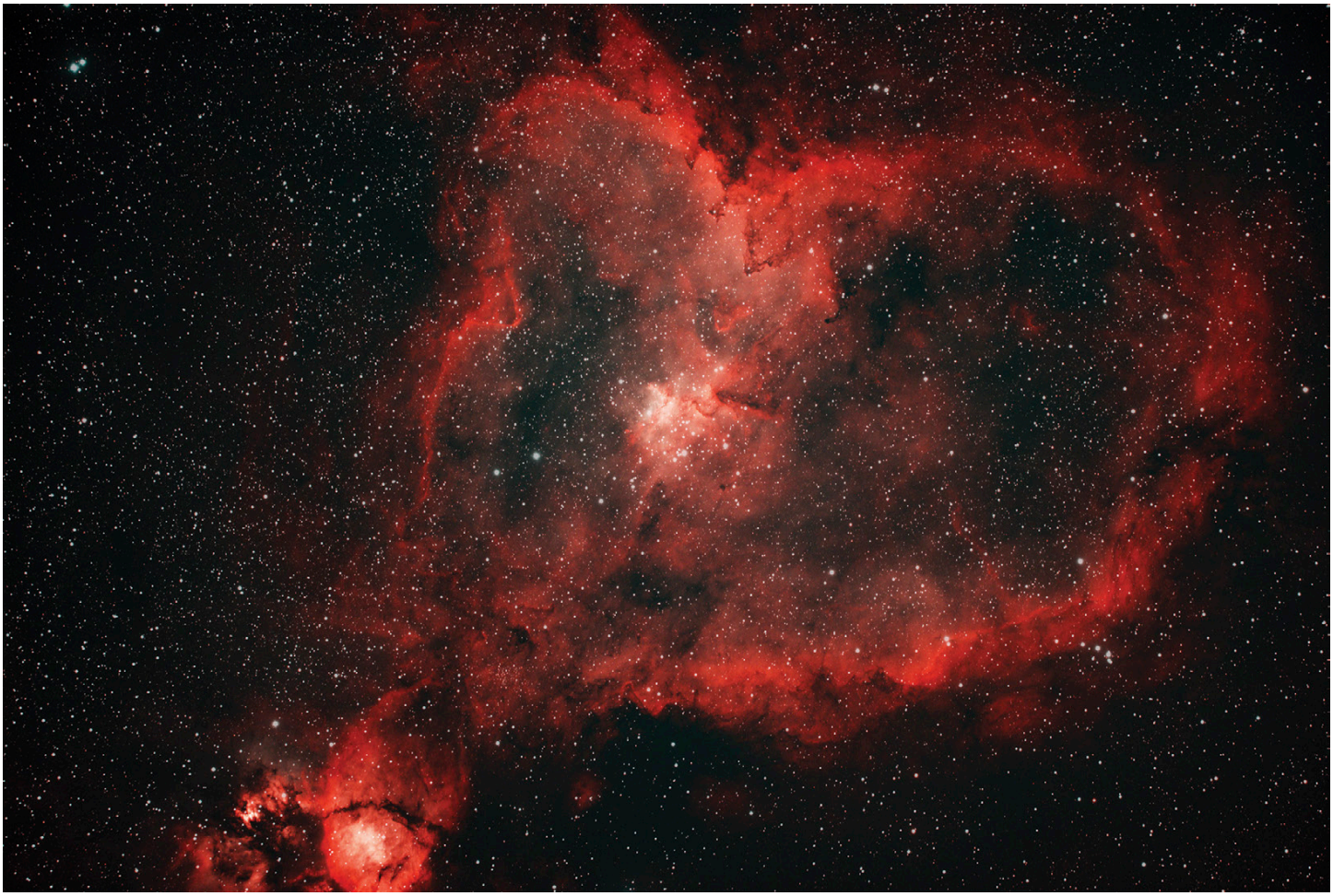


Comet 62P/Tsuchinshan by Gary Garzone on Feb. 3

Comet 144P/Kushida by Gary Garzone by Feb 10

Comet 12P/Pons-Brooks by Gary Garzone on Feb. 10

IC 434, “Horsehead” Nebula by Gary Garzone on Feb. 15



IC 1805, “Heart Nebula” by Jim Pollock on Feb. 14 -- thanks for the valentine Jim!

NGC 4173, “Box Galaxies” by Jim Pollock on Feb. 19

Orion Nebula by Martin Butley

Marty reprocessed some data from 2019 with his FLI 16200 camera and Takahashi FSQ 130.

One minute exposures in RGB. One half hour each for a total of 1.5 hours.

The challenge in processing the Orion Nebula is the tremendous dynamic range.

Some of the new tools in PixInsight help with this - especially the Generalized Hyperbolic Stretch.

"Cave Nebula" by Martin Butley on Feb. 14

Red is red plus both Ha and SII, Green is green plus OIII, and Blue is blue plus OIII, These were taken from Hygiene with a Takahashi 130 FSQ refractor on an AP Mach2 mount with an ASI 6200 monochrome camera and Chroma filters.

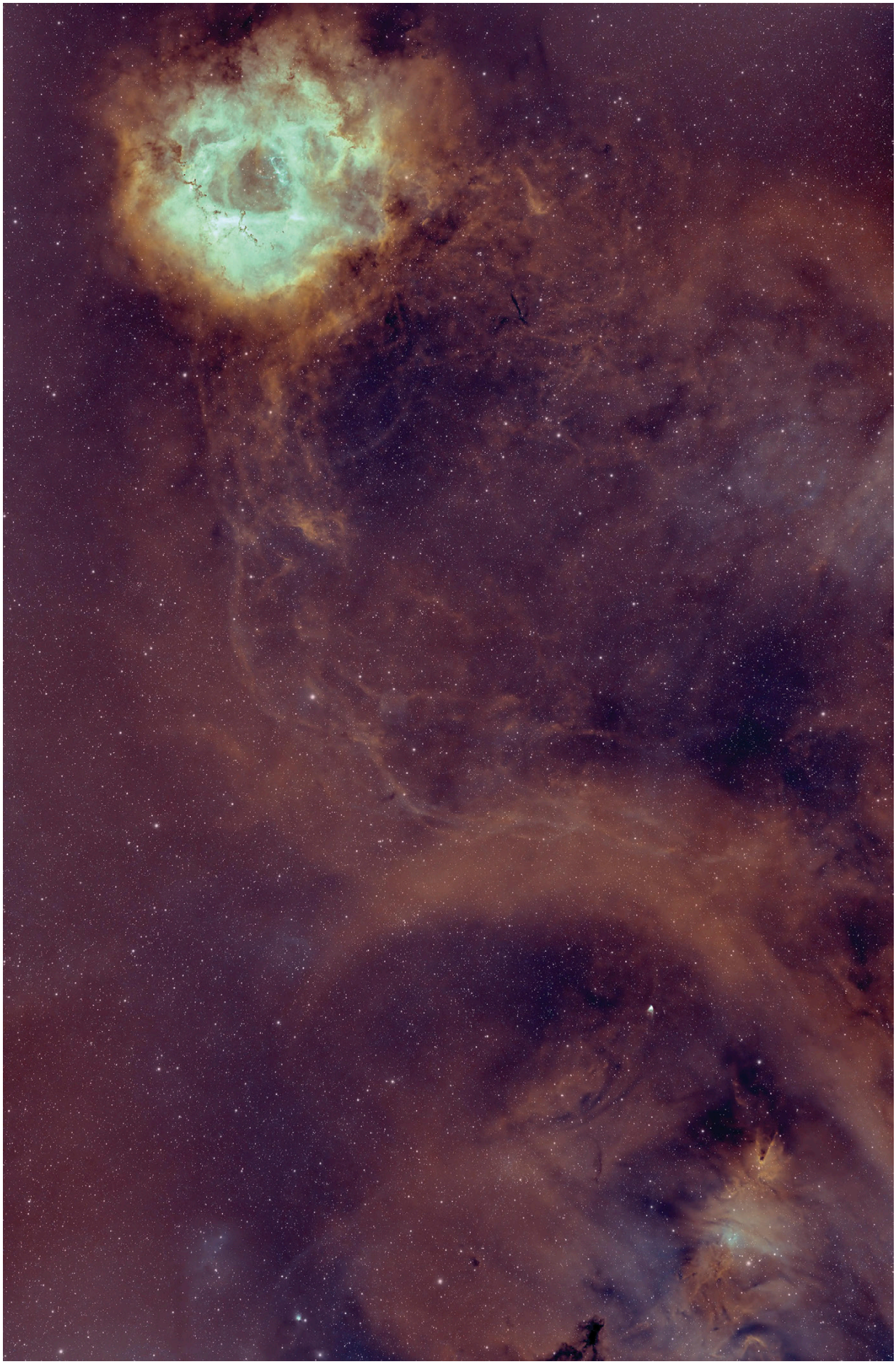
South of the Lagoon Nebula Mosaic by MJ Post on Feb. 12

2-panel mosaic of the region just east and north of the Lagoon Nebula (M8). It was constructed using new mosaic tools in PixInsight that seemed to work well in this instance. Captured with CDK14 scope at DSNM, luminance filter, and ASI 6200MC camera and dwelled about 2 hours on each frame. Cataloged objects in the composite include ICs 1275, 4685, and 4681; NGC 6559; and SH2-29. Field of view is about 0.85 x 1.0 degrees.

Abel 426 by MJ Post on Feb. 13

M. J. applied StarXterminator to the Abell 426 image. Every bright spec of light you see here above the noise is a galaxy. He estimates there are 600 galaxies visible in this image.

NGCs 869 and 884, "Double Cluster" by MJ Post on Feb. 4



SNR.G205.5+00.5 in HOO by Stephen Garretson on Feb. 5

GSC.2412.865 Area by Stephen Garretson on Feb. 12

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Longmont, CO 80506

Horsehead and Flame Nebula
by Martin Butley